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EDUCATION IN AFRICA

THE recent report of the Parliamentary and Scientific Committee referred to a memorandum from the Colonial Sub-Committee dealing with questions relating to education, agriculture and fisheries, health, forestry and the future of the Colonial Development and Welfare Fund, in which the dependence of Colonial development on the application of modern scientific knowledge in the utilization of natural resources was emphasized. This in turn depends very largely on the technical competence of the indigenous populations and their ability to participate in the process, and it is from this point of view, quite as much as from that of political development, that the study of educational policy and practice in British Tropical Africa recently issued by the Nuffield Foundation and the Colonial Office is of outstanding interest*. It includes the reports of two missions, one, led by Mr. A. L. Binns, to East and Central Africa, and the other, led by Dr. G. B. Jeffery, to West Africa (both of which were financed by the Nuffield Foundation), and the record of the proceedings at the subsequent conference at Cambridge in September 1952, of which Sir Philip Morris was chairman. An analysis of the reports is printed elsewhere in this issue (p. 1134).

The Cambridge conference, at which the Colonial Office and the United Kingdom were represented, consisted mainly of representatives of Colonial territories, chiefly in territorial teams forming an almost complete cross-section of the educational world of British Africa. It was the first occasion for a review of the whole groundwork of education in Colonial territories by those concerting it since 1925, when a general policy for British education in Africa, based upon the work of the Phelps–Stokes Commissions of 1920–21 and 1923–24, was outlined in a "Memorandum on Educational Policy in British Tropical Africa"; it was thus also the culminating event in a long process. Soon after the War, it was realized that, in view of political changes, the extent to which education was becoming rooted in African soil, and the urgency of some problems in educational policy and affairs in Africa, needed careful review and, in many respects, to be thought out afresh.

The approach favoured was more intimate and less formal than that of a Royal Commission. The small groups of experts who, under Mr. Binns's and Dr. Jeffery's leadership, visited Africa were able to initiate in each territory they visited discussions fundamental to the problems of each particular territory. The two reports they prepared formed the basis for the conference discussions, and for that purpose the conference was divided into five groups in which education was discussed from the different vantage points of responsibility and control; the expansion of the educational system; the teaching profession; organization and curriculum; and education and the adult.

* African Education: a Study of Educational Policy and Practice in British Tropical Africa. (Produced on behalf of the Nuffield Foundation and the Colonial Office.) Pp. xii+187. (London: Crown Agents for the Colonies, 1953.) 8s. 6d.

The purpose of the conference was not to make policy which should thereafter be imposed upon the territories which were participating, or to fix a common pattern of education on a considerable proportion of a vast continent. It did not seek to pass general resolutions. Its object was to place on record the best views which could be formulated and expressed, so that hereafter those responsible for shaping policy or carrying out educational work should find in the record of the conference opinions and conclusions which had been refined by discussion but which had not been pressed into uniformity. As Mr. Oliver Lyttelton writes in his foreword, the volume poses the problem of education as a challenge and a stimulus to education, and it may well point the way to fresh advances. Moreover, unlike the reports of the Phelps–Stokes Commissions, the conclusions of which were limited to specific territories, the Binns and Jeffery reports present conclusions of general validity even where they were not specifically adopted by the conference.

Throughout the work of the two groups which visited Africa and of the subsequent conference, the method adopted was devised to ensure that the wisdom and experience of those in the field were freely drawn upon in any conclusions which might be reached, and that the processes in which they had participated might have the maximum chance of being relevant and fertile. Certain limitations were, however, placed upon the study. It was limited in the first place to the education of Africans; and higher education, apart from a brief section on university education, so far as affecting the work of the schools and the training of teachers at Makerere College, was omitted, because the ground had already been covered by the Asquith and Elliot reports and because university policy in Africa is under constant review by the Inter-University Council. Furthermore, the development of higher technical education is excluded for similar reasons, and technical education is only considered in connexion with different types of secondary schools and with the needs of industry.

These limitations do not seriously detract from the interest of the report for the scientist as such. With the general approach rather from the point of view of what needs to be done than from that of the available resources and the best means of distributing them, the report is concerned above all with the foundations on which higher education, both at the university- and the technical school-level, can effectively develop. It is concerned, too, with the conditions in which the services of the technician, the technologist and the university graduate can be most effectively utilized and, by implication rather than by precept, it gives a good deal of guidance as to the right priorities to be adopted where means are straitened and some choice of objectives has to be made. The Binns report went so far as to suggest that the churches engaged in educational work in Africa should consider very seriously whether some of their thought, energy and control should not give place to a larger effort in the education of adults, and by this it included the preaching and practice of the Christian religion.

This suggestion that the churches should abandon their thousands of small scattered 'bush' or unaided schools and divert the money and energy thus freed into the channels of adult education was not endorsed by the conference. Nevertheless, it was generally agreed that more could be done to encourage and co-ordinate the work which the churches are doing in the field of informal education, either by association with official training schemes or by participation at the advisory level in national and regional planning. The suggestion, moreover, illustrates two dominant characteristics of both reports and of the subsequent conference discussions, namely, the belief in the necessity of a spiritual basis of all education, and the insistence that a fully comprehensive educational system cannot be developed in isolation from the development of central and local institutions of government.

The Binns report, for example, claims that the situation in Africa amounts to a moral crisis, and suggests that Governments in East and Central Africa should abandon their attitude of neutrality in relation to religion. A public statement on a belief in the necessity for a spiritual basis for education in its widest sense would encourage those already at work and provide inspiration for future development. Both reports, however, agreed in emphasizing the importance of building up moral leadership. The Jeffery report suggests, for example, that it would be a great contribution to progress at this critical stage if those upon whom the responsibility for moral leadership rests could come to a clearer realization of what they have in common in their appreciation of the fundamental human values. "If leaders in all branches of African thought could come together in a united and public testimony of fundamental values they would make a lasting contribution to education on the West Coast."

The Jeffery report urges further that the moral progress of any people depends partly upon the vision and vigour of its prophets, but more upon the example of those men and women who, by reason of consistent and faithful lives, are judged worthy by their fellows. This passage, insisting on the relation between morals and character training, was quoted with approval by one of the study groups at the conference; but the most impressive feature of the conference proceedings is the unanimity of all five study groups in their reports that education must not be purely secular but must have a spiritual basis. This basis can only be assured if religious bodies are formally associated with government bodies in the control of education, and furthermore, if training colleges are staffed with those of such high moral character as will fit them to exercise a sound influence upon their students.

This first point, moreover, is linked up with the second, for, as the Jeffery report points out, character is trained in the exercise of responsibility, and in the developing society of West, East or Central Africa to-day, a prime problem is to determine the appropriate measure of responsibility that can be given at any particular moment in relations between child and teacher, between teacher and institution, and

between institution and local or central government. To the extent to which this is wisely determined, the effectiveness of education both as an instrument of stability and of change largely depends. It is to be noted, for example, that the Binns report points out that education is inseparable from life, and urges the closest co-operation between the departments of education and agriculture at all levels; in consequence, while it recognizes that scholarship is of first-rate importance, it advocates recruiting an increased number of Europeans for the African education service primarily with the view of their ability to inspire in their pupils a deep and abiding affection for rural life and the things of the countryside. All practical work in the schools, moreover, should have a real meaning to the pupils, and should never be allowed to become mechanical drudgery.

The vision of education which inspires these reports is that of the united concern of a people for the right upbringing of its children and the improvement of its national life. Success depends upon the co-operation of parents, teachers, administrators, leaders in public affairs and of all who care for the future of their country. An essential element in it is to provide full opportunities for creative activity; and to the extent to which it inculcates also that respect for truth, which is the characteristic educational value of science, it can play an essential part in developing the sense of common citizenship—a sense which experience has already shown is developed not so much through political institutions themselves as from participation in some kind of leisure-time education or activity that exacts loyalty and demands enthusiastic endeavour. What is sought is, in effect, a more liberal education for Africans based on their own African environment and on their own way of life—an education, as the Binns report puts it, designed to enable Africans to understand their environment and to lead the most complete life that is possible in it.

The emphasis on the spiritual basis of education is strongly reflected in all that is said about the training of teachers. The importance of quality here is stressed as much as, if not more than, the need for keeping education keyed with the traditions and needs of the people concerned. The supply of teachers lies at the very heart of the educational problems of the West African coast regions; but the Jeffery report nevertheless maintains that raising the educational standard for admission to training is one of the most urgent educational needs. An increase in the number of really good teachers should be the spearhead of educational progress, and there is no single aim in which effort could be concentrated to greater advantage.

This reflects the conclusion of Lord Hailey's "African Survey", that the most pressing need in popular education in British territories is the improvement of standards of teaching and better means of control. The Binns report likewise suggests that in the teachers' training colleges is to be found the remedy for many of the serious weaknesses in African education at present. In the teachers' training colleges, as well as in schools, it suggests, a moral code should be inculcated by the active formulation of good habits and the development of a strong community life. The staffs of training colleges should be selected as examples of what their students should become, and morality should be presented to students as a matter of principle and of service to the community, while great attention should be paid to fostering "initiative and responsibility". The recruitment, conditions of service and training of teachers are discussed at some length in this report, and were also considered by one of the five study groups at the subsequent conference; nor was there difficulty in reaching agreement on the main aspects of policy.

The points which received general support were not, in fact, new, and what is most noteworthy about them is rather the sense that they are essential, and that if governments really wish to encourage the development of education they must break down whatever obstacles have hitherto prevented action along the lines indicated. Some of these points, notably that about continuity of staffing, are peculiarly matters for government action: attention is directed throughout this report to the harm which is done when teachers are moved to suit the administrative convenience of an education service without regard to the effect on the teacher or the institution concerned. Besides this, there is an equally noteworthy sense of the way in which the training of teachers should be in line with the needs and the development of the community. For example, it is recognized that any distinctive African contribution to the world must be based on the African's love and respect for the mental inheritance of his people, much of which is enshrined in language. There is warning against the danger of discarding good values from tribal life, while taking from Western culture, not its spiritual strength but its materialistic weakness. With the insistence on the necessity of a good general education as a basis for successful technical education goes that on the need for a close connexion between technical education and industry. Likewise, it is recommended that technological education should be developed to keep pace with industrial expansion and to enable Africans to make their maximum contribution as skilled workers in accordance with the opportunities available in each area; and in view of the great importance of agriculture in African life, agriculture should be strongly represented both in teaching and research at the university-level. Attention is also directed to the practical help which could be given to educational policy and practice by such university studies as those at Makerere College into the causes of wastage in the schools, or at the Institute of Education into intelligence testing as applied to East Africa.

In all this is implicit the belief that administrative advance must come to terms with political realities. If Africans are to find adequate expression for their new hopes and aspirations, they must have opportunities for serving the public interests of their country in their immediate communities. Real service, moreover, needs an element of responsibility, and participation in local affairs is both a present

service and a preparation for the larger services which the future will require of them. Here there is also recognized the danger of a dichotomy between the literate young and illiterate elders. Some means must be found of ensuring that some at least of the older generation are carried along with the general movement.

This is one reason for the report's emphasis on what it terms 'informal' or adult education, rather than mass education, though the methods used may be both formal and informal; and its importance appears again in the report recently prepared by the Hansard Society* on problems involved in developing parliamentary institutions in Colonial territories. The other main reason for such emphasis appears in regard to finance. Both the Binns and the Jeffery reports urge that the proportion of government expenditure which is devoted to education requires increasing; but the study group at the conference at Cambridge which considered the expansion of the educational system paid little attention to the question of finance, and the conference as a whole did not appear to come to grips with the real issues here. It was left for one of the speakers in the discussion to suggest that in present circumstances the expansion of education is an emergency problem and must be treated on an emergency basis. Education should not be regarded merely as one among a number of services which compete for whatever share of the revenue remains after providing for justice, communications, administration, the national debt and other essentials.

Perhaps the great value of the whole report on African education may lie in its demonstration that education is an essential service and that, as the Binns report points out, "if it is deprived of the means to do its work well, all the departments will suffer". If education is to receive not merely its present ten or twelve per cent of the revenue but a greatly increased allocation, this point must be clearly understood both by the Government itself and also by the community on whose support that government rests. To the extent to which educational developments are supported from Colonial Development and Welfare Funds, it is important that public opinion in Great Britain should also understand what is involved. It is, however, of increasing importance that in those territories in which Africans themselves are associated with administration and government, there should be a clear understanding of the whole nature of educational policy and its relation to the needs of the community, and of the effort and sacrifices which are required to pursue consistently a policy of expansion which will meet African needs.

There is much else of great interest in this report. It is constructive as well as critical. It puts its finger firmly, as did Dr. G. B. Jeffery in an earlier report, on the weaknesses and dangers of the examination system, and it shows very clearly how valuable is the help which the British universities and individual teachers from Great Britain could give in meeting African needs in this field. It is as clear as from the Hansard Society's report already mentioned that, unless such help is forthcoming, and unless the governments concerned face the problems set out here with determination and a sense of urgency, there is little hope that parliamentary institutions will either develop or function in the Colonial territories of Africa. Political progress cannot be isolated from economic, social, cultural and spiritual progress. Even in such a comparatively advanced democracy as Britain, a primary lesson of a satisfying education, namely, that there are no civic rights without civic duties, and that liberty can only be earned, has been imperfectly learned. Educational policy and practice in Africa are of supreme importance, because their adequacy and efficacy determine both the standards of administration and the effectiveness of whatever forms of democratic institutions may be adopted, the functioning of the whole organization of government, the reality of co-operation in the tasks of government at local and at central levels, and equally the pace of economic and social development upon which the welfare of the society depends. The report on African education sounds the right note of urgency and indicates practical steps to be taken. That from the Hansard Society does not merely put the issue in its true perspective; it also indicates substantial reasons for believing that the parliamentary system may yet succeed in the Colonial world, and that the educational effort which Britain as well as the Colonial peoples is summoned to make in Africa may be undertaken with confidence.

* Problems of Parliamentary Government in Colonies: a Report prepared by the Hansard Society on some of the Problems involved in developing Parliamentary Institutions in Colonial Territories. Pp. x+154. (London: Hansard Society, 1953.) 12*s.* net.

PLASTICITY UNDER PRESSURE

Studies in Large Plastic Flow and Fracture

With Special Emphasis on the Effects of Hydrostatic Pressure. By Prof. P. W. Bridgman. (Metallurgy and Metallurgical Engineering Series.) Pp. x+362. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 72*s.* 6*d.*

DURING the past twelve years or so, Prof. P. W. Bridgman has been making experiments on the plastic flow and fracture of metals, and other solids, when these are subjected to large hydrostatic pressures (for example, 450,000 lb./sq. in.) superposed on the stress system that actually causes flow and failure. The starting-point for the work was his discovery, just before the Second World War, that the ductility of ordinary steels increases enormously in the presence of such high pressures, the reason for this being of course that, while the hydrostatic stress squeezes the atoms together, so that fractures cannot start inside the body, it does not stop the atoms sliding past each other. It appeared likely that this discovery would shed light on the unusual behaviour of armour plate under high-speed penetration, particularly since it was known that the stresses developed around the nose of a projectile during penetration are of a similar magnitude; and these considerations led Prof. Bridgman to begin a systematic investigation of the effect, under the sponsorship of the United States National Defence Research Committee and of the Watertown Arsenal.

Much of this work was written up during the War in government reports. These have now been declared available to the public, but still remain largely unknown. As for the rest of the work, only a part of it has been recorded and published until now. A result of this poor publicity is that some of the experiments have already been duplicated by other people, unaware of their existence. To remedy this situation, Prof. Bridgman has written the present book, in which he has collected together the work into a coherent and easily accessible form.

It is an unusual book, not only for what it contains but also for how it is written. Presented in a very personal style, in which the first person singular is often used, it amounts almost to a highly polished log-book of the author's researches. In places there are accounts of historical details, not only of the ups and downs of particular experiments, but also of the negotiations surrounding their planning and publication. The general reader may feel that neither of these latter is meant for him, that the experimental details are only for those about to make similar researches, and that the negotiations have been brought in only because the author wished certain facts about them to be placed on record.

To set against the tedium of these passages, the general story of the experiments makes fascinating reading. Chapters are included on the tension of steel under hydrostatic pressure, on similar experiments with other metals and various mineral substances normally considered brittle, and on two-dimensional tension, compression, brinell indentation, punching, wire drawing and extrusion, all under hydrostatic pressure. The effect of external pressure on cavities is studied with several materials, and various other experiments are described dealing with large strains in one-dimensional and two-dimensional compression, and in torsion and shear. Finally, an account is given of the effects of prior deformation under one type of stress system on subsequent behaviour under other types. Theoretical analyses of stress distribution, including that at the neck of a tensile specimen, are made at various places throughout the text, and in these the author's exceptional physical intuition guides him surely over otherwise hair-raising routes to some very reasonable solutions.

Only a few of the many interesting points can be mentioned here. Chapter 4 describes an extremely ingenious method of making tensile tests, under hydrostatic pressure, which dispenses completely with shoulders at the ends of the gauge-length and so avoids their associated stress concentrations; this is essential when making tensile tests on brittle substances. In Chapter 5 it is shown that, under high compressive stresses, single crystals of alumina deform plastically on slip planes; the appearance of the deformed crystal in the photograph of Fig. 62 is strikingly reminiscent of that of a compressed zinc crystal that has been deformed by kinking. The great ductility which can be obtained under high hydrostatic pressures is demonstrated in numerous ways. One of the most interesting of these is in wire-drawing, where reductions in diameter and intensities of work-hardening can be achieved that far surpass ordinary experience; there is surely the basis of an important industrial process here.

To conclude, this is a book which will undoubtedly prove most valuable to those concerned with the mechanical properties of solids under extreme pressure, whether in a laboratory, a forge, a mineshaft or an armoured fighting vehicle.

A. H. COTTRELL

FOURIER SYNTHESIS OF CRYSTAL STRUCTURE

Fouriersynthese von Kristallen und ihre Anwendung in der Chemie

Von Prof. Werner Nowacki. (Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften, Chemische Reihe, Band 6.) Pp. 237. (Basel: Verlag Birkhäuser, 1952.) 34.30 Swiss francs.

THIS book, on the use of Fourier series in crystal structure analysis, is the outcome of lectures given by Prof. W. Nowacki to advanced students during the summer and winter sessions of 1948–49. The author presumes some knowledge of crystal structure analysis on the part of the reader, thus making it an advanced text-book on the subject. Although the information given is not more recent than 1949, there are copious lists of references to each section, which makes it an excellent reference book to the teacher, the research worker and the student in X-ray crystallography.

The book is divided into two parts, each of which might be brought under the more general headings of structure determination and technical aids for computation, respectively. The first seven sections of Chapter 1 are taken up by an introduction to Fourier syntheses and, by using Lonsdale's "Tables", the author derives the structure factors and the electron density expressions for the space groups $P2_1/c$, $P2_12_12_1$ and Pna. The accuracy of determining atomic positions is next taken up in relation to errors arising from the termination of series effects with appropriate corrections. The author, however, is not in favour of applying an artificial temperature factor to the observed F-values since, as he rightly points out, such corrections tend to introduce more errors than those they were intended to eliminate—namely, the diffraction effects of an abruptly terminated series. A discussion follows on methods of refinement which include Bragg–Lipson structure-factor graphs, molecular transforms, differential synthesis, and methods of least squares and steepest descent. The last two sections of the chapter, which should have appeared earlier, form the basis of structure analysis. Determination of absolute $|F|$-values are discussed, including the use of Wilson's very useful statistical method, and lastly a brief survey is carried out of the more usual methods of phase angle determination—namely, trial and error methods, the use of isomorphous replacements and the heavy atom technique, the use of Harker–Kasper inequalities, Buerger's implication diagrams and the 'fly's eye'.

Part 1 of the book is concluded by a detailed treatment of Patterson syntheses, with sections dealing with its extensions in the form of Harker and Buerger syntheses, respectively. A full description is given of space-group determination using Buerger syntheses, and Table 19, incorporated as a booklet, gives the hundred and twenty extinction groups useful for space-group determination. These two chapters form the basis of this book. It is rather unfortunate that it appeared at a time when some significant advances were being made in the technique of structure determination, three examples of which may be quoted. First, Wilson's statistical methods used as aids in space-group determination are now in general use and possibly supersede the methods suggested by Buerger syntheses. Secondly, (F_o-F_c) syntheses and differential syntheses are likely to be

used to a greater extent for the accurate location of atomic centres rather than the method of steepest descents. Thirdly, Lipson and Taylor's development of optical methods for viewing molecular transforms and for the determination of phases has given a new turn to our concepts of structure determination. Nevertheless, these recent developments do not in any way diminish the usefulness of this book.

The second part of the book deals with methods of calculating Fourier series and structure factors. There is a full description of the Beevers–Lipson method, and brief references are made to other electro-mechanical aids, of which the Hollerith punched-card technique has come to be widely used.

The book as a whole is well produced, well indexed and well referenced. It is to be hoped that Prof. Nowacki will bring out a second edition in which are incorporated the more recent advances, thus adding to the merit of an already useful book which can be fully recommended.

C. H. Carlisle

PHYSICS MONOGRAPHS FOR STUDENTS

Fundamentals of Thermometry
By J. A. Hall. Pp. 48.

Practical Thermometry
By J. A. Hall. Pp. 51.

Soft Magnetic Materials used in Industry
By A. E. DeBarr. Pp. 62.

The Magnetic Circuit
Powder Cores, Ferrites, Permanent Magnet Materials, and Miscellaneous Magnetic Materials. By A. E. DeBarr. Pp. 62. (Monographs for Students.) London: Institute of Physics, 1953. 5*s*. each.

THE Institute of Physics by its various publications, particularly the Physics in Industry series of monographs and the monthly journal, the *British Journal of Applied Physics*, has greatly advanced the study and development of applied physics and provides the industrial physicist and research worker with up-to-date factual information. The proper training of applied physicists, a matter of paramount importance, has also occupied the attention of the Institute, and it issues National Certificates in applied physics jointly with the Ministry of Education and the Scottish Education Department. However, the usual text-books on physics are not primarily concerned with the practical applications and with instruments, and thus the Institute has started to publish a new series of "Monographs for Students" which have been specially written for general reading by students attending courses for the Higher National Certificate in applied physics; these books constitute a valuable and important contribution to the literature of applied physics, and a stimulus and aid to the student.

The first four volumes in this series are remarkable for their excellence in content and production. The graphs are particularly clear and easy to read, though some diagrams have suffered from over-reduction. "Fundamentals of Thermometry" and "Practical Thermometry" are companion volumes: in the former attention is concentrated on the International Temperature Scale, and in the latter the instruments and techniques described are largely those recommended by, or used at, the National Physical Laboratory, where the author is a senior principal scientific officer and is actively engaged in the testing and development of temperature-measuring instruments. "Soft Magnetic Materials used in Industry" and "The Magnetic Circuit" are also companion volumes, and, in case the reader may be misled by these titles, it is perhaps well to add that the physical basis of, and introduction to, magnetic properties is given in the first of these two monographs, while in the other are details of powder cores, ferrites and other magnet materials. The domain theory of ferromagnetism, antiferromagnetism and ferrimagnetism all receive adequate treatment.

The monographs are short but handy booklets in stiff paper covers; they should have a wide circulation.

S. Weintroub

D.C. ANALOGUE COMPUTERS

Electronic Analog Computers (D–C Analog Computers)
By Dr. Granino A. Korn and Theresa M. Korn. Pp. xv+378. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 59*s*. 6*d*.

THIS book is concerned with electronic analogue computers of one class only, namely, those in which the variables are represented by voltages and in which the circuits are direct-coupled throughout. The authors are primarily concerned with the use of such machines for solving sets of ordinary differential equations in which time can be used for representing the independent variable. There is a section dealing with machines for solving sets of simultaneous algebraic equations, but this subject is not dealt with at length.

The authors are much too concerned with practical details of design to attempt to define the field in which D.C. analogue computers are of use, although they wax enthusiastic on p. 3 about a computer wired up from scrap parts on a 'bread-board' in two hours at negligible cost and ready to furnish needed information with fair accuracy. But it is clear from the book that the authors have been primarily concerned with the use of analogue computers in aircraft design, both for investigating the behaviour of servo systems, non-linear damped oscillators, etc., and also as simulators, for example, in the testing of autopilots when a computer can be used to simulate the behaviour of an aircraft. In these applications the main drawback of analogue computers—poor and uncertain accuracy which falls almost to nothing when the magnitude of the variable considered changes by a large factor—is not greatly in evidence. This is partly because the results are interpreted by engineers who understand the working of the computer and know when the results given are likely to be trustworthy. I am not sure whether the authors would agree that analogue computers are less useful for dealing with differential equations which arise in more mathematical contexts—for example, in theoretical physics.

The greater part of the book is concerned with theoretical and practical aspects of the design of D.C. amplifiers, integrators, differentiators, multipliers, function generators and other computing circuits. This part of the book is admirably practical and should be of use to anyone concerned with the design of electronic devices which include computing elements. The section on the choice of scale factors should similarly be of interest to users of analogue computers.

M. V. Wilkes

Semimicro Qualitative Analysis

By Prof. Paul Arthur and Prof. Otto M. Smith. (International Chemical Series.) Third edition. Pp. xi+285. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 34*s*.

THIS book is intended to provide an elementary course in inorganic qualitative analysis on the semi-micro scale, covering the commoner cations and anions, but excluding separations in presence of phosphate. Ten chapters, roughly half of the text, give an outline of the theory involved, each being followed by a series of questions for the student, and including, where relevant, typical worked examples. The remainder gives a survey of experimental technique, clearly illustrated by diagrams, followed by analytical schemes for cations and anions. Each tabular scheme is preceded by a brief general survey of the reactions of the ions included, and followed by a series of notes on the experimental procedures.

The analytical schemes for the cations follow mainly the classical pattern, but a useful alternative method for the analysis of the iron group, based on a modified Ford–Williams separation of manganese and chromium, is given. This should minimize adsorption errors such as occur in the usual hydroxide–sulphide method for this group. The tabular schemes are clearly set out, and the accompanying notes cover most of the difficulties likely to be met with by students without overloading the text. Confirmatory tests for particular ions are based, as they should be, mainly on the correct carrying out of the separation procedures, but a short section lists alternative special reagents for use in doubtful cases.

The practical section is evidently based on laboratory experience of the methods described in the text, and this, together with the appended notes, makes the book a reliable introduction to the theory and practice of qualitative analysis. J. A. MAIR

Bibliographie des langues aymará et kičua

Par Paul Rivet et Georges de Créqui-Montfort. (Université de Paris: Travaux et Mémoires de l'Institut d'Ethnologie, Tome 51.) Vol. 1 (1540–1875); pp. xlii+500; 3,200 francs. Vol. 2 (1876–1915); pp. v+656; 3,500 francs. (Paris: Institut d'Ethnologie, 1951–52.)

THESE two volumes, which are a product of forty years of work, comprise a list, with short critical notes on each item, of practically everything which was printed in Quichua and Aymara from the Spanish Conquest down to 1915; and, although the authors invite additions and corrections, it is unlikely that they have missed anything of importance. The title pages of a good many of the more important works are reproduced in facsimile, and an index is promised but has not yet appeared, so it will presumably follow in a subsequent volume.

The introductory chapter is brief, and, besides describing the objects and scope of the work, it sets the stage by giving a short account of what the authors conceive to have been the general linguistic situation during the time of the Incas. In the course of this they repeat some statements with which many linguists disagree, but they themselves stress the immature state of linguistic studies of South America, so this need cause no surprise. Most of the material is connected with the evangelization and religious instruction of the Indians, and in the nature of things little can come from native sources, so a relatively large proportion of this chapter is devoted to a discussion of the original MSS. of the native drama Ollantay.

Having heard Prof. P. Rivet introduce and present these volumes to two recent international congresses —the Peruvianists in Lima, and the Americanists in Cambridge—I can testify to the enthusiastic reception which they have already received from many scholars, and have no doubt that they will be equally warmly welcomed by all who are concerned with the historical and linguistic study of South America.

G. H. S. BUSHNELL

Automatic and Manual Control

Papers contributed to the Conference at Cranfield, 1951. Pp. xi+584. (London: Butterworths Scientific Publications, Ltd., 1952.) 50*s*. net.

EACH paper in this volume is a contribution to fundamental design technique, and as such would merit scientific publication, in one form or another, in the usual way. In considering a symposium of such papers, however, the questions which arise are: Is the publication of the collection, as a whole, worth while, and does it fulfil the objects which the editorial committee set itself? According to the preface, the volume is intended as a work of reference for those engaged in control equipment design, and also as a book which might valuably assist those possessing a general background knowledge to branch out into more specialist fields. It must suffer, as a work of reference, by its very structure, which makes it impossible to use as a normal referenced text-book; nor can it be particularly comprehensive, as much of the basis of design technique has to be taken for granted. To offset this, one has the advantage of the direct research experience of specialists, much of the material being a model of presentation, logical in sequence, lucid and well illustrated. Although a point has been made of covering specially the mathematical techniques employed in the theory, and though wide in its applied interests, the work must prove a difficult one for students. This does not detract from its inherent value, and in the class of published symposia it must certainly take a very high place. A. J. KENNEDY

King Solomon's Ring

New Light on Animal Ways. By Konrad Z. Lorenz. Translated from the German by Marjorie Kerr Wilson. Pp. xxi+202. (London: Methuen and Co., Ltd., 1952.) 15*s*. net.

WELL known in scientific circles for his elaboration of the 'releaser' and 'imprinting' mechanisms in animals, Dr. Konrad Lorenz is now seeking to interest a bigger audience in his life's work. In "King Solomon's Ring" he tells of insects, fishes, ravens, geese, jackdaws and dogs with rare insight arising out of great creative powers allied to direct observations often carried out in most painful and trying circumstances the like of which few naturalists have experienced. As a result, Lorenz has stories to tell which, because of their very truth, grip the reader in wonder and admiration. The accounts themselves are embellished by a style of writing which, while never less than scientific, is at once lucid and simple, as well as amusing thumb-nail sketches which have been contributed by the author himself. If the book has any blemish, it is that the remarkably fine chapter on jackdaws deserves a volume to itself. In the meantime, one gratefully welcomes this book which, of its kind, has known no peer for many a year. T. H. H.

STOCK-TAKING ON AFRICAN EDUCATION

DURING the ten years of its existence, the Nuffield Foundation has made a signal contribution to the welfare of the British Commonwealth and Empire. Through its fellowship and scholarship schemes many promising young men and women have been assisted to travel abroad from their own countries, to improve their knowledge and enrich their experience, so that they may return home more capable of serving their peoples. During the Foundation's first five-year period, its main Colonial policy was to provide material and social aids to ensure that selected scholars obtained the qualifications which the Colonial Office deemed necessary for the specific posts in government service to which the scholars aspired. On their side, the Colonial administrations undertook to absorb all successful scholars. They did not always honour this pledge. So, it is particularly gratifying to note the successful co-operation between the Nuffield Foundation and the Colonial Office which has resulted in the document under review*.

The report on African education is in three parts, each representing a milestone in an endeavour which lasted two years. The first section is a record of the discussions and recommendations of the West Africa Study Group which spent the last six months of the year 1951 visiting the territories of Gambia, Sierra Leone, Gold Coast and Nigeria. The second part of the book deals with the deliberations of the team of educational experts which visited East and Central Africa at the same time. The work of these two study-groups culminated in a conference which was held in King's College, Cambridge, last September. The proceedings of that conference are chronicled in the third part.

Not since the Phelps–Stokes Commissions of the early twenties has so much thought been given to the vital matters of Colonial education, or so many illustrious educationists been involved in the process. The East and Central African group consisted of Mr. A. L. Binns (chairman), chief educational officer for the Lancashire County Council; Prof. B. A. Fletcher, director of the University of Bristol Institute of Education; and Miss F. H. Gwilliam, assistant educational adviser to the Secretary of State. The West African group consisted of Dr. G. B. Jeffery (chairman), director of the London University Institute of Education; Mr. F. T. Arnold, H.M. staff inspector for secondary schools; Dr. Josephine Macalister Brew, educational adviser to the National Association of Girls' Clubs and Mixed Clubs; and Mr. E. W. Woodhead, county education officer for the Kent County Council. The meetings at Cambridge were held under the chairmanship of Sir Philip Morris, vice-chancellor of the University of Bristol, who, as Mr. Oliver Lyttelton states in his foreword to this report, must be credited with a large share of the success achieved and the goodwill shared. A large delegation from the Colonial Office attended the Cambridge conference as visitors, and each of the Colonies and Protectorates affected sent official representatives and unofficial observers. Those from West Africa falling in the latter category were mainly politicians holding the newly created portfolios in education, and the value of their contribution must have lain in their immense goodwill and large-hearted co-operation.

An interesting feature of the conference at King's College was the small number of formal lectures delivered; and those that were given came from a strange combination of authoritative sources: Prof. Margaret Read, professor of education and head of the Department of Education in Tropical Areas, University of London, referred to world-wide implications of the African education movement; Prof. B. W. Bigelow, Columbia University, New York, stressed the need for co-operative action in solving the educational problems of Africa; and Sir John Maud, permanent secretary to the Ministry of Education, outlined the value of the British system of separating questions of party politics from those which are purely educational.

The terms of reference of the two teams of educationists which visited Africa in 1951 precluded them from considering in detail not only the political influences at work in the territories under study, but also university work and development. Higher technical education was also not to be emphasized. The points covered included teacher training, elementary and secondary education, the relationship between government and voluntary agencies, financing educational projects, and the curriculum. These aspects were emphasized in the 'working paper' which was drawn up by the Advisory Committee on Education in the Colonies, and dispatched to East, West and Central Africa, prior to the visits of the experts.

The Jeffery and the Binns reports are different in a number of fundamental ways; in one the emphasis is on broad principles, with occasional references to relevant details. The other consists of innumerable tiny dots placed together as in a half-tone reproduction of a photograph. Of course, the issues were not the same and could not possibly have been placed in the same perspective.

The East Africa group was faced with all the complexities of life in a British territory where Anglo-Saxons have made their permanent homes, side by side with Asiatics and Africans. Their hands were further manacled by being told to avoid educational matters appertaining to Europeans and Asiatics. Since Kenya, Uganda, Northern Rhodesia, Tanganyika and Nyasaland are no longer African lands, as such, but have been declared to be places where a life of partnership must be sought, as between members of the different races, any broad study of educational policy must take into consideration the different practices in vogue, and place them in a composite setting which alone can truly reflect the *status quo*. It is the absence of such an approach that makes the Binns report so frustrating to read.

The main thesis of the East Africa Study Group would appear to be that Africa is an agricultural country, and we must do our best to make it remain so. We must educate the Africans for life 'on the land'. So far as possible, the African must be made to pay directly for this education, in fees as well as in taxes. It does not matter if the central government spends several times as much money on European education than on his. It does not matter if European agriculture depends for its productivity on African labour.

If this is accepted as the line of argument, then the recommendations of the Binns report begin to make sense—the first phase of primary education

* African Education: a Study of Educational Policy and Practice in British Tropical Africa. (Produced on behalf of the Nuffield Foundation and the Colonial Office.) Pp. xii+187. (London: Crown Agents for the Colonies, 1953.) 8s. 6d.

should be curtailed from six years, as it is now, to four years; and the aim should be to give 50 per cent of all children of school-age four years schooling in the local vernacular. Swahili, which is the only indigenous lingua franca, should be discontinued in schools, and its place taken by relatively unknown local tribal languages. It should be the aim of the educational authorities to provide a further four-year course for 10 per cent of the school-age population, and four years secondary schooling for 2 per cent of all the children who should be at school. It is preferable to site African schools not too near the towns. European supervisors should be placed over trained African teachers, for the time being. The prerequisite of a university degree for highly paid European teachers should sometimes be waived to make it easier to recruit men with an agricultural bent, who, by their presence in African schools, would inspire the 'natives' to become good farming folk.

However, the report of Mr. Binns and his colleagues is valuable on account of the stress it lays on (*a*) the importance of research into those aspects, for example, wastage, of African education which now appear baffling; (*b*) founding teacher colleges of 100–200 students, with practising schools attached; (*c*) the encouragement of female education by relieving transport difficulties; (*d*) providing bedsheets, spoons, lavatories, and similar elements of prime necessity in boarding schools; (*e*) making teachers competent to teach Africans English in the intermediate and secondary schools; (*f*) erecting a suitable moral and religious basis to all education. Perhaps the most important—certainly the most wise—utterance in the entire report is the following: "The ideal school, if it were acceptable to parents, would be an interracial school. There are no insurmountable practical difficulties in the way of interracial education at any stage, but there are many difficulties in men's minds. Initiatives in this direction must therefore be the pioneer efforts of individuals who feel a call to experiment in this field . . . and because the task of government is eased as racial tensions are eased, such initiatives should receive moral and financial aid from the Government". One cannot help wondering why this does not appear in the official recommendations of the group.

Dr. Jeffery and his co-workers, who are convinced that "the potentialities of the West African have been demonstrated by actual achievement", had an easier task. The Phelps–Stokes Commission of 1920 had a Gold Coast member, Dr. Aggrey, on it; and the implementation of its recommendations have probably been pursued much farther in West Africa than elsewhere.

But there are still many problems awaiting solution. For example, the group expressed its anxiety over the possibility of the local governments taking over responsibility of recurrent expenditure for education when the Colonial Development and Welfare Funds come to an end. The question of raising capital for the great educational expansion that is called for is another cause of worry for those responsible for educational development in West Africa. About a third of the probable annual expenditure of £3 million by the Nigerian Government will be absorbed by higher education. Is this proportion too high, in view of the great need for extending the frontiers of elementary education in the rural areas? Is it wise, at this critical stage, to build up an extravagant medical school to train only a handful of clinicians annually?

On the perennial question of the relationship between voluntary and governmental agencies, the commission agrees that a functional amicable relationship is gradually being built up in West Africa. The system whereby government grants voluntary bodies financial aid in the running of their schools is commended here, as in East Africa. The group records a consensus of informed African opinion that an entirely secular education is undesirable; but does not insist that the religious basis should be Christian. West Africa has a considerable Moslem population, and there are other religious groups.

Although the Jeffery committee commends the "Accelerated Development Plan for Education in the Gold Coast" on both educational and administrative grounds, the bottleneck may prove to be the recruitment of staff. It is the same problem all over again. African graduates do not take up the teaching profession because the prospects of promotion are not great. Besides, expatriate staff receive much better emoluments, even under the African Governments which are emerging on the West Coast.

The Cambridge conference reconsidered all these questions under the following heads: *A*, Responsibility and Control; *B*, Expansion of the Educational System; *C*, Teaching Profession; *D*, Organization and the Curriculum; *E*, Education and the Adult. The reports of the five study-groups of the conference and the plenary discussions on them are printed in this volume in an edited form. Mr. W. E. Ward, editor of the Colonial Office journal *Overseas Education*, in his private capacity put the material together. On the whole, the conference appears to have favoured the Jeffery approach rather than the Binns; but many a reader will feel regret that the names of the speakers have been omitted from the dialogues.

As Sir Philip Morris states in his epilogue to the conference, its chief purpose was, obviously, in human relations. The whole purpose of education is in human relations; for, in the language of the West African study-group, "education is the complex of actions and reactions between persons by which a nation prepares itself for its future by the dissemination of knowledge and skills and valid ideas of human dignity and fellowship". OLUMBE BASSIR

NUCLEAR PARTICLE LABORATORY AT QUEEN MARY COLLEGE, LONDON

THE inauguration on June 23 of the Nuclear Particle Laboratory at Queen Mary College, University of London, marks what is probably the first occasion on which applied nuclear physics has been officially instituted in Great Britain as part of the undergraduate engineer's education. The laboratory has, however, a dual function to fulfil. In addition to the provision of practical work for undergraduates in the field best described as nucleonics, it also makes available facilities for research work relating to accelerating machines and gas discharges, where high-voltage electrical engineering, electronics, and nucleonics have a common frontier.

Taking the undergraduate work first, the subject designated 'nuclear energy' is offered to third-year mechanical and electrical engineers as one of a

number of options from which part of the final year's work is selected. (This is now usual in schools of engineering in North America.) The course is therefore somewhat superficial compared to the other aspects of engineering, which receive three years study. However, it would be wrong to allow greater specialization at this stage in the new subject, even though it may be expected to develop extensively during the active life of the present undergraduate population. The lectures are based mainly on the recently declassified information on nuclear reactor design, but also on general aspects of nuclear physics related to engineering. To obtain a suitable laboratory course to support such lectures, use is made of artificial radioactive sources, and particularly, antimony–beryllium neutron sources. These enable measuring techniques to be studied, which relate directly to engineering uses of radioisotopes as well as providing substance to some aspects of reactor theory, such as neutron distribution theory and calculations relating to cross-sections. It is hoped that it will eventually be possible to extend these experiments by the use of material enriched in fissile components. The whole subject is of general interest to engineers, as quite apart from the practical uses for which nuclear energy will become available, its development is an outstanding example of the logical and scientific processes by which the formulæ of theoretical physics can eventually be translated into engineering reality.

The research facilities offered by the Nuclear Particle Laboratory centre around the high-voltage equipment, which is not yet complete. A 1-MV. electrostatic generator has been in use, however, for examination of discharges in continuously evacuated systems, and similar work has been carried out at 100–200 kV. using rectifier sets. An impulse generator for 1 MV. shortly to be finished will at first be used on the same programme, though it is planned to develop, from this, a high-intensity electron accelerator. Interest has so far tended to be concentrated on the discharge phenomena at residual gas pressures, because this is often a practical engineering limitation in the design of accelerators, particularly D.C. accelerators of the electrostatic type. It has been found that preliminary discharges are obtained in such systems with characteristics which have not previously been investigated in any detail. Further apparatus in use includes a 5-MV. single impulse air-cored betatron which can be employed to give short X-ray impulses at higher voltages; but the intensity is, of course, much lower. An electron microscope is also in operation, providing both a further weapon for investigation of discharges (in so far as these originate in electrode surfaces) and an example of high-voltage equipment of interest to the biological faculties. Either a further D.C. generator or a radio-frequency accelerator will be installed next year, depending upon development of the present research groups.

The range of engineering activity has now extended over so wide a field that many feel that the undergraduate courses at universities may be in need of quite drastic modification. There is a wide divergence of opinion as to what form such modification should take; but perhaps a majority of critics believe that more emphasis on fundamental principles is needed, with less time spent on design study. The Nuclear Particle Laboratory at Queen Mary College, with an over-riding emphasis on the fundamental theory of matter, is a step in this direction.

MECHANISM OF PROTOPLASMIC MOVEMENT

By Prof. WILLIAM SEIFRIZ
University of Pennsylvania

THE streaming of protoplasm and the apparently autonomous movement of particles within it have long been problems in biology, and many have been the theories to explain them. Protoplasmic flow has been attributed to every imaginable force, from surface tension to electro-osmosis, without much evidence to support any of the hypotheses.

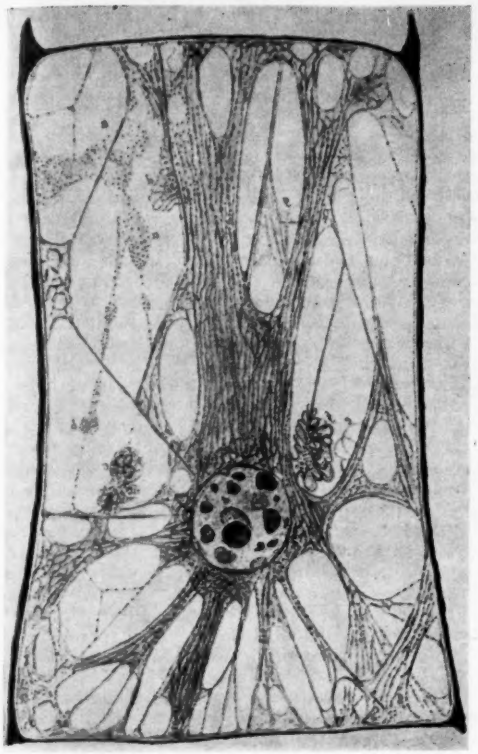
Early in college training, Prof. E. A. Andrews directed my attention to the movement of protoplasmic particles. He referred particularly to a form of activity which was neither cyclosis nor the "vulgar pedesis dance discovered by Brown in dead regions of plants. *These* particles", said Prof. Andrews, "are travelers, going places". In ciliated Protozoa of the closely related families Vorticellidæ and Stentoridæ there are particles less than 1 mμ in diameter which move ten to one hundred times their own length in a second or two. They may pass close to one another, proceeding in opposite directions[1].

In subsequent years my attention was centred on the flow of protoplasm. Recently, I again turned to the particles, hoping to find in their motion a clue to the mechanism of protoplasmic streaming. Isolated cells from cultures of plant 'cancers' served as material—kindly supplied by Dr. R. J. Gautheret.

Some years ago I[2] advanced a theory of protoplasmic flow based on the rhythmic pulsations of a slime mould. The peristaltic waves, when accelerated by time-lapse photography, are readily seen. They much resemble the trains of waves in a stimulated muscle fibre. There is no question of the presence of rhythmic pulsations; but, though synchronized with the fifty-second period in reversal of flow, they are not the cause of cyclosis. One of the weaknesses of the theory was its failure to explain the simultaneous flow of protoplasm in opposite directions in parallel currents. One occasionally sees in Protozoa, but better still in a sheet of protoplasm in some species of slime moulds, as many as nine channels of flow in which adjoining currents flow in opposite directions, 'rubbing shoulders' as it were, without mixing, and without an evident wall between the two (top centre in the accompanying figure).

All the foregoing difficulties were apparently solved by a 'new' theory of cyclosis which appeared several years ago in four articles from the pens of six authors[3–6]. Frey-Wyssling[3] deserves credit for the theory, though Meyer and Mark[6,7] claimed a twenty-year priority, in so far as the theory applies to muscular contraction. The suggestion made by all six authors is that within the protoplasmic stream polypeptide chains fold and unfold, the protein molecules moving forward like an army of caterpillars, carrying the surrounding medium with them.

The curling and uncurling of molecular fibres is an attractive mechanism by which to account for the flow of protoplasm. It is, however, a pure assumption, permissible only if certain conditions are met. Curling may be accounted for; thermic agitation will do it. Stretching, however, is another matter. At every point where folding occurs sufficient energy must be transmitted to stretch, or untwist, the folded chain in opposition to thermic agitation. The



A typical plant cell (after Heidenhain)

proponents of the theory present no evidence to show that this energy is available, and that there is also present the complex mechanism necessary to use the energy and accomplish the untwisting. In addition to this negative evidence, I offer the following observations on the movement of protoplasmic particles in disproof of the caterpillar hypothesis.

The first hint which ultimately led to a clarification of the problem came early in my work when I observed three independent rhythmic pulsations in a plasmodium. Kamiya[8] later increased this number, and referred to the plasmodium as a polyrhythmic system. This means that there are many excitation foci within one protoplast.

Plant cells often form delicate protoplasmic threads along which move particles of numerous kinds. The particles are frequently of greater size than the diameter of the thread which carries them. It is not possible, therefore, that the particles are moved by the feeble stream of endoplasm in the lumen of the protoplasmic thread, for they are embedded in the outer cortical layer. The situation is comparable to a 5-mm. sphere moving within a 5-mm. tube which has a 1-mm. bore and a 2-mm. wall.

Final proof that a synchronized migration of curling and uncurling protein chains within the stream is not the mechanism of protoplasmic flow is to be had in the occasional erratic activity of the particles. The movement of the particles, when they are of fat, cannot possibly be autonomous, and this holds for mitochondria as well. The Belgian school of cytologists is convinced that mitochondria are capable of self-repulsion. The French school, on the contrary, is opposed to such an assumption.

Protoplasmic granules along a strand usually move smoothly and continuously as if carried by the stream, each particle maintaining its position in line. Frequently, however, striking disturbances occur. Several particles will suddenly increase their speed and hurry away from the others. Sometimes one or two particles will reverse their course and proceed in the opposite direction; a collision more than likely resulting. Two or more momentarily quiet particles may suddenly assume activity and move rapidly away from each other. Occasionally, two particles will approach each other, collide, and then proceed in the opposite directions. None of these erratic movements can be accounted for by a protoplasmic stream, and, as I have said, it is quite impossible that fat droplets should have autonomous motility.

Certain of the behaviourisms described above are duplicated by the waves which traverse muscle fibres. Particularly striking is the approach and collision of two waves, precisely as in a protoplasmic thread, except that particle is substituted for wave. One is forced to the conclusion that the mechanisms are identical.

That the foregoing phenomena are not restricted to protoplasmic threads and muscle fibres becomes increasingly evident as one surveys the whole field of cellular activities. I shall refer only to those shown me by my colleagues at the Sorbonne and the Pasteur Institute. Dr. J. Comandon and Dr. P. de Fonbrune[10] demonstrated, in hyphæ of fungi, the three types of motion which I have described, namely, the passive transport of particles by the protoplasmic stream, Brownian movement, and an erratic activity here brought on by artificial irritation. The last of these is the type of motion which I believe to be due to nerve-like impulses emanating from excitation foci in the living cell.

A similar situation exists during mitosis of the *Triton* red blood cell[10]. Here, just prior to cell division, the nucleus commences to rotate, and continues doing so for some minutes. There is no cyclosis to account for it. The nucleus is apparently responding to a stimulus originating in the cytoplasm, that is, it is moved by excitation forces.

Very striking was the sudden assumption of activity by the centrosome, or centrosome area *en masse*, in polymorphonuclear cells from mammalian blood. During mitosis the centrosome oscillates half the length of the cell, with a rhythmic period of thirty seconds. Because of the motion, the surrounding cytoplasm is stretched, indicating high elasticity. There is no cyclosis. I had the pleasure of observing this behaviour of the centrosome in blood cells in the laboratory of Dr. A. Policard and Dr. M. Bessis[11].

With the exception of the passive movement of particles when carried by flowing protoplasm, all the foregoing activities in living cells are the result of stimuli arising at excitation foci.

Somewhat similar is the activity of chondriosomes described by Buvat[12].

Before attempting an analysis of the force responsible for protoplasmic movement, I should like to emphasize its universality by directing attention to the resemblance of the rhythmic phenomena which occur in nerve, muscle and the relatively undifferentiated protoplasm of the slime mould. The Myxomycetes, or Mycetozoa, are a very

lowly form of life, yet they pulsate rhythmically and show peristaltic waves just as does the musculature of man. The pulsations in both cases are accompanied by a rhythmic rise and fall in electric potential. Kamiya[14] has measured this potential in the Myxomycete *Physarum*. Any statement on the nature of the force involved in protoplasmic movement must include the similar activities in muscle and nerve.

In explanation of protoplasmic movement one cannot turn to electrical currents such as are conducted along metal wires. Adrian[13] swept away all such analogies in reference to the nervous impulse as long ago as 1912. We must, therefore, seek a force which meets, so far as possible, all biological conditions and has the full recognition of the physical chemist. There are a number of attractive possibilities. Phase phenomena and the forces responsible for the stability of coacervates are active in living systems. In these fields Joly and Dervichian[15] have done much which has a direct and significant biological bearing. Dobry[16] directs attention to some extraordinary analogies between the behaviour of coacervates and protoplasm. Weissenberg[17] has described the flow of coacervates against gravity, which is a protoplasmic quality.

But it is to 'fields' that I wish to turn for an interpretation of the impulses which activate protoplasmic movements. Let me first say that, in rejecting the part which fibres are said to play in the streaming of protoplasm, I do not thereby ignore the obvious part which fibres play in living material where they are needed and can be used. In the cellulose framework of plants, in muscle, tendon and in nerves where the linear form serves well, Nature uses fibres. But a fibre is of no use for doing mechanical work if there is no place to attach it. Our present problem is not one of tensile strength but of propulsion.

Debye[18] has well interpreted fields such as surround polar molecules and colloidal particles. Molecules similar to H_2O, NH_3 and HCl are surrounded by static electric fields which convert them into dynamic systems, into electrically charged elementary particles. A second molecule coming within close range of such a dipole will acquire a field, or electric moment. Being thus polarized, it will interact with the first molecule. The work of Debye and others, notably London, has led to the now widely accepted fact that polar molecules are enveloped by electric forces which may be derived from pure coulombic interactions between charges. These are essentially short-range forces which do not extend beyond three or four molecular diameters. Long-range forces will accomplish more.

The total force with which a particle, consisting of many molecules, will act on a second particle may be ascertained by integrating over the first sphere and arriving at the reaction between this sphere and a molecule in the second sphere. In a similar manner may one integrate the molecules in the second sphere and thus arrive at the final total reaction. Such a procedure leads to the prediction that in appropriate circumstances short-range molecular forces may build up to appreciably strong long-range forces. Overbeek[19] has recently made direct measurements of the molecular attraction between parallel glass plates at distances of the order of the wave-length of visible light (5000 A.).

If we turn to the still larger particles of lyophobic colloidal suspensions, then we have additional forces, namely, the familiar electric charge on the surface, due to preferential adsorption or to dissociation at the surface of the particle. The range of the coulombic interaction of these colloidal charges is determined by the depth of the ionic cloud surrounding the particle.

If, now, we determine the total interaction energy between two colloidal particles, we find that under suitable conditions it shows a pronounced maximum at an appreciable distance. It is for this reason that some colloidal suspensions are so stable and their coagulation time so great.

With the foregoing background we can apply Szent-Györgyi's[20,21] hypothesis of muscular contraction. The double layer of ions which surrounds a muscle fibre will set up an electric field. If a wave of depolarization travels along the surface, this will have the same effect as if we had pulled electrodes along the axis. The precise mechanism is not known; but it is only necessary to assume that a local depolarization is generated which runs parallel to the fibre axis. If, instead of a muscle fibre, we have a thread of protoplasm within a cell, then a wave of depolarization giving rise to a field parallel to the axis would carry particles and fluids with it.

Whether we are dealing with a single isolated fibre (lower left in figure), or with 'fibres' separated by cortical layers of oriented molecules lying parallel to each other so as to form a sheet of protoplasm (upper centre in figure), is the same in the end. Impulses travel back and forth, rhythmically or spasmodically, moving the cytoplasmic fluid and the particles in it.

Whatever our assumptions and hypotheses may be, a few facts remain clear: that the folding and unfolding of protein fibres is an assumption without the support of an adequate energy; that there is no evidence that fibres can function mechanically in a free droplet of protoplasm; that the mechanism of protoplasmic streaming is situated in the cortical layer, not in the endoplasm; and that rhythmic impulses traverse fibres of muscle, nerve and elementary protoplasm alike, measurable as differences in potential and visible in muscle and protoplasmic threads as trains of waves; and that it is these impulses which carry nerve transmissions and move protoplasm.

I wish to express my thanks to Dr. R. J. Gautheret and Dean Albert Chatelet, of the Sorbonne, for the hospitality which made this research possible.

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OBITUARIES

H. A. P. Jensen

I FIRST met Hereward Jensen at the British Association meeting in Newcastle in 1949. We fell into conversation, and among other subjects we discussed the Nature Conservancy. Since he was clearly so interested in its work, I suggested to him that he might offer his services to the Conservancy as physiographer and naturalist. It was not for some considerable time after this talk that I realized that the then director-general of the Conservancy, Captain Diver, had a few weeks before asked me if I knew Jensen. Although he was only on the Conservancy staff for three years, he had made a name in that time and set a high standard of research and administration which will not easily be forgotten. His death at the age of thirty-two, the result of an accident in the train on his way home from a meeting of the Royal Geographical Society on May 11, was a tragedy. He leaves a widow and two small children.

Jensen was at school at Oldershaw (Wallasey), and took a degree under Prof. P. M. Roxby in the Department of Geography at Liverpool. On account of disability, he was not called up for active service in the War, but for nearly three years was a (temporary) civilian officer with the Intelligence Division of the Naval Staff at the Polar Research Institute, Cambridge, where he contributed to a number of the Admiralty geographical handbooks. In 1944 he was appointed to an assistant lectureship in geography at Manchester, and for the four years previous to his joining the Nature Conservancy he was a research officer at the Joint Intelligence Bureau, Ministry of Defence.

He was particularly interested in coastal studies, and had made intensive investigations in the Dee estuary. As a member of the Conservancy he extended his view, and had a remarkably good knowledge of much of the coast of Great Britain. Because of our common interest in the coast and our connexion with the Conservancy, we visited many parts of the coast together, and I soon realized how sound was his judgment and how reliable his mapping and investigations. Last year we worked together on Winterton Ness, and this year we visited part of the flooded areas together, and had made plans for a full investigation of the effects of the floods on the north Norfolk coast. He had also travelled in the Netherlands and Sweden, and had prepared the manuscript of a book on Sweden. Last year he was one of the delegates from the Nature Conservancy at the International Geographical Congress at Washington, and in America he was able to visit the south-eastern States and also make a tour of the eastern Nature reserves.

Hereward Jensen's death has been a grievous shock to his many friends, who will miss his cheerfulness and kindness of heart. Geographers and naturalists, whether they knew him personally or by reputation, will know that Nature conservation in its widest and best sense has lost a most able exponent. The members and staff of the Nature Conservancy mourn the loss of a valued friend and colleague.

J. A. STEERS

WE regret to announce the following deaths:

Prof. Alexandre Bigot, formerly professor of geology in the University of Caen and *correspondant* for the Mineralogical Section of the Paris Academy of Sciences, on April 20, aged eighty-nine.

Prof. D. Hanson, professor of metallurgy and director of the Department of Metallurgy, University of Birmingham, on June 12.

Mrs. Cora Brooking Hodson, formerly secretary of the Eugenics Society, and later honorary secretary of the International Federation of Eugenics Organizations, on May 21.

Prof. H. Rein, a director of the Max-Planck Institute for Medical Research, Heidelberg, aged fifty-five.

Dr. C. E. Walker, formerly lecturer in histology in the University of Liverpool, on June 6, aged eighty-two.

NEWS and VIEWS

Physics in the University of the Witwatersrand: Prof. F. R. N. Nabarro, M.B.E.

DR. F. R. N. NABARRO, who has been appointed to the chair of physics in the University of the Witwatersrand, was educated at Nottingham High School and New College, Oxford. He took a first-class honours degree in physics in 1937, and a year later obtained the same degree with first-class honours in mathematics, with distinction. During 1938–39 he was senior scholar of New College. In 1939 he became research assistant to Prof. N. F. Mott at the University of Bristol, and later joined the Army Operational Research Group of the Ministry of Supply. During 1945–49 he was Royal Society Warren Research Fellow, working in the University of Bristol, and in 1949 he was appointed lecturer in metallurgy in the University of Birmingham, which post he now holds. He was awarded the M.B.E. in 1946, a Beilby Memorial Award in 1950, and the D.Sc. degree of the University of Birmingham in 1952. During the War, Dr. Nabarro worked first on the theory of radar aerials and then on the accuracy of radar and the effectiveness of anti-aircraft fire and searchlights. His studies of anti-aircraft shell fragmentation led to similar work on ground targets, and he organized the calculation of the theoretical effectiveness of shell-fire and bombing, and compared this with the observed correlations between fire support and British casualties in army operations. Apart from his work during the War, he has concerned himself largely with problems in the physics of metals. He has been particularly interested in the dislocation theory of slip in metals, and has contributed a number of important papers to this subject in recent years. He is now engaged on a book summarizing the mathematical problems arising in this theory. He is the author of some twenty-five papers of high scientific quality, and he has made notable contributions to the modern theory of metals.

American Geophysical Union: Award of the William Bowie Medal

DR. BENO GUTENBERG, director of the Seismological Laboratory, California Institute of Technology, Pasadena, California, has been awarded the William Bowie Medal by the American Geophysical Union (Committee on Geophysics of the National Research Council). Dr. Gutenberg, who was born in Darm-

stadt, Germany, is known for his many contributions in the broad field of geophysics and related fields. He studied at the Technische Hochschule of Darmstadt and the University of Göttingen, where he obtained the degree of doctor of philosophy in 1911. He went to the United States in 1930, and became an American citizen in 1936. He has been professor of geophysics at the California Institute of Technology since 1930, and director of the Seismological Laboratory since 1947. He is author or co-author of many outstanding work in geophysics, including "Grundlagen der Erdbebenkunde", "Seismicity of the Earth", and extensive contributions in "Internal Constitution of the Earth", of which he was also the editor. He is president of the International Association of Seismology and the Physics of the Earth's Interior, of the International Union of Geodesy and Geophysics.

The Greenwich Meridian

When the Octagon Room of the Royal Greenwich Observatory was taken over by the National Maritime Museum, it was felt that the old meridian marked on the pavement was too inconspicuous; the Ministry of Works has accordingly installed a new line consisting of a brass strip let into a band of white stonework laid across the pathway outside the Observatory. The Greenwich Meridian was adopted as the Prime Meridian by the world in 1884 at the suggestion of the United States Government, which had called an international conference to consider the matter. It was defined as the north–south line running through the Airy transit circle in the Observatory. In the past, many prime meridians have been used. Eratosthenes naturally used the meridian of Alexandria, of whose great library he had been appointed librarian in 240 B.C.; Ptolemy, to avoid the difficulty of having both east and west longitude, used that of the Fortunate (Canary) Islands, the most westerly land known, so that all longitude should be measured eastwards. At one time there was an attempt to mate the prime meridian with the line of no magnetic variation; but the impossibility of unifying two lines which were inclined to each other at an angle and the impracticability of tying down hypothetical meridians running through the Canary Islands or the Azores had by the nineteenth century led many countries to adopt the meridians of their principal observatories. At one time England commonly used the meridian of St. Paul's.

Expedition to Mt. Wrangell, Alaska

A joint expedition is being made this summer by members of New York University and the University of Alaska with the purpose of establishing a scientific observing station, principally for cosmic rays, on Mt. Wrangell in Alaska. The expedition will be led by Prof. Serge A. Korff, professor of physics in the College of Engineering, New York University, who will be the scientific director and principal scientist, and by Dr. Terris Moore, president of the University of Alaska, who will act as administrative director and be responsible for establishing the station. Although Mt. Wrangell (14,006 ft.) is not the highest mountain in Alaska, being topped by a number of peaks, of which the highest is Mt. McKinley (20,269 ft.), it has been chosen because its unusually flat top makes it an excellent landing-place for aeroplanes fitted with skis. Incidentally, it is the only 'live' volcano in Alaska, and it may be possible to utilize the steam that issues at the north-west end of its summit. A preliminary party is at present climbing the mountain, and experimental landings will be made by Dr. Moore in his special Piper Super-Cub aeroplane at convenient spots as they are discovered by the climbing party. By this means it is hoped to build up a series of landing places at various heights, and eventually to establish a safe landing field on the summit by which the station can be supplied with huts and other stores and permanent equipment. The proposed station, which will be the most northern-most cosmic-ray station in the world, will be operated on an inter-university basis, whereby interested organizations, by contributing *pro rata* to its maintenance, may send observing personnel and equipment there.

Royal Society's Depository of Unpublished Mathematical Tables

Since the publication of the first list (see *Nature*, **169**, 526; 1952) the following tables have been accepted into the Royal Society's depository of unpublished mathematical tables: Table de factorisation des nombres $N^4 + 1$ dans l'intervalle $3000 < N \leqslant 6000$ (A. Gloden); solution of the equation $(y'')^2 = yy'$ and two other equations (Admiralty Research Laboratory); dictionary of Laplace transforms (J. Cossar and A. Erdélyi); tables of Fresnel's integrals (D. H. Shinn); tables of the error integral of a complex variable (J. K. Skwirzynski); table des solutions de la congruence $x^4 + 1 \equiv 0 \pmod{p}$, $600000 < p < 800000$ (A. Gloden); tables of the complex Jacobian zeta function (National Physical Laboratory); tables of binomial coefficients (National Physical Laboratory); tables of Multhopp's influence functions (National Physical Laboratory); integrals of Bessel functions (J_0 and Y_0) (National Physical Laboratory); table of $\int_0^{2\pi} J_1^2\left(2k\sin\frac{\theta}{2}\right)\cos^2\frac{\theta}{2}\,d\theta$ (National Physical Laboratory); tables of two functions occurring in the theory of the reflexion of electromagnetic waves from infinite cylinders (National Physical Laboratory); table of an integral used in calculating profiles of water waves (National Physical Laboratory); tables of the Langevin function and its inverse (A. Young and T. Murphy). Further information about these tables can be obtained on application to the Assistant Secretary, Royal Society, Burlington House, London, W.1.

Political Activities of Civil Servants

Following the announcement on November 1, 1949, that the Government would give immediate effect to those recommendations of the Masterman Committee in its report on the political activities of Civil servants which would free some 450,000 Civil servants from existing regulations, the Government indicated that, before taking final decisions on the general principles of the report, joint discussions through the machinery of the National Whitley Council were desirable. The report of the joint committee afterwards appointed has now been published as an appendix to a White Paper in which the Government's proposals are detailed ("Political Activities of Civil Servants" (Cmd. 8783). Pp. 16; London: H.M.S.O., 1953; 6*d*. net). The statement points out that the extent to which Civil servants should be free to take part in political activities must be considered in the light of two conflicting principles. The desirability, in a democratic society, of all citizens having a voice in the affairs of the State and of as many as possible of them playing an active

part in public life has to be set against the imperative demand of the public interest for the maintenance of political impartiality in the Civil Service and for confidence in that impartiality. In other words, it is an essential part of the structure of government in Britain that the Civil Service should not only be impartial but also be seen to be impartial.

The Whitley Committee suggested that between the two classes proposed by the Masterman Committee an intermediate class should be created, and the Government has agreed that this could be done without detriment to the interests of the State or the reputation of the Civil Service for political impartiality. The problem is where to draw the line, and the members of the Whitley Committee are themselves unable to reach agreement. The Government proposes to draw the line so as to include the five groups which both sides of the Committee proposed to include, but excluding junior executive officers and analogous grades, and to bar canvassing to Civil servants restricted in their political activities while allowing it by permission only to those in the intermediate group. The decision, which will give substantial political freedom to a further two hundred thousand Civil servants, appears to be reasonably circumspect, while experience demonstrates that the increased freedom will be used with good sense and discretion. Some 62 per cent of the Civil Service is now completely free of restrictions, and only 16 per cent is barred from participation in national political activities; and to many of those who seek it, permission to participate in local government may be given.

Standard Solutions of Phosphorus-32

It has been found by the Isotope Division, Atomic Energy Research Establishment, Harwell, that phosphorus-metabolizing moulds grow readily in solutions containing phosphorus-32 used as radioactive standards and may cause losses of specific activity in the solution of up to 50 per cent in one week. To inhibit their growth, an addition of 1 per cent formaldehyde is therefore made to such solutions before dispensing and measurement. All solutions thus treated are clearly marked and carry a poison label.

Congress of the Universities of the British Commonwealth

The Seventh Quinquennial Congress of Universities of the Commonwealth will be held in Cambridge during July 13–17 under the presidency of Marshal of the Royal Air Force Lord Tedder, chancellor of the University of Cambridge. Practically every university and university college in the British Commonwealth will be represented by a delegation of teaching and executive officers led by its vice-chancellor or principal, making a total of more than four hundred persons, and in addition there will be observers from many learned bodies and a party of ten university presidents nominated by the Association of American Universities. The present Congress is the seventh of the series organized (except for interruptions caused by the two wars) at five-yearly intervals since 1912 by the Association of Universities of the British Commonwealth (formerly the Universities Bureau of the British Empire), the previous meeting having taken place at Oxford in 1948. The chairman of the organizing committee is Sir Philip Morris, vice-chancellor of the University of Bristol and chairman of the Association. The Congress provides an opportunity for the free exchange of views on matters of current importance to the universities of the British Commonwealth, and the following subjects will be discussed at the sessions: government and universities, administration and academic duties, academic mobility in the Commonwealth, higher technological education, and admission and selection of students. A general symposium will also be held on the question: What subject or subjects to-day are best fitted to fulfil the role played previously in the university curriculum by the classics? By invitation of Sir James Duff, warden of the Durham Colleges in the University of Durham, there will be a meeting of vice-chancellors, presidents and principals of member universities of the Association of Universities of the British Commonwealth at St. Mary's College, Durham, during the week beginning July 6. This conference will be devoted to private discussion of inter-university relationships and problems of administrative and educational policy common to the various universities of the Commonwealth. Both the above meetings will be private; but further information can be obtained from the Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

University of Birmingham

The following have been appointed lecturers in the University of Birmingham: Dr. G. W. Greenlees (physics), R. W. Murray (zoology), Dr. W. T. Pell-Walpole and S. G. Glover (metallurgy) and P. S. Gelling (ancient history and archæology). The title of reader in systematic bacteriology has been conferred on Dr. K. A. Bisset, lecturer in bacteriology in the University.

The University Department of Engineering Production has received a further gift of £57,400 (under seven-year covenant) from Joseph Lucas and Co., Ltd., the firm which originally endowed the Department, and it is intended that this sum be used for the establishment of a centre for continued studies in engineering production and management. The University has acquired a house at 16 Norfolk Road which is being altered and refurnished and which will shortly be opened as the University of Birmingham Institute for Engineering Production. The aim of the Institute, which will be directed by Prof. T. U. Matthew, Lucas professor of engineering production, is to develop a series of short residential courses in engineering production and management subjects for executives in responsible posts in manufacturing industries. The work of the Institute will be reviewed and liaison with industry maintained through an advisory board, on which a number of industrial leaders will sit with the vice-chancellor and members of the Faculty of Science. It is hoped that the Institute will be opened on July 16 with a fortnight's course on "The Application of Work Study".

University of Leeds: Appointments

The following appointments have been made in the University of Leeds: Prof. T. L. Bywater, at present Strathcona Fordyce professor of agriculture in the University of Aberdeen, to be professor of agriculture and head of the Department of Agriculture; Prof. R. F. E. W. Peel, professor of geography in the University, to be head of the Department of Geography in succession to Prof. A. V. Williamson (see *Nature*, June 6, p. 1002). The title and status of reader have been conferred on the following members of the University: Dr. A. D.

Walsh (physical chemistry) and Dr. A. S. Leah (applied thermodynamics). E. W. F. Seymour has been appointed lecturer in the Department of Physics.

Geological Society: Officers and Council

The officers and council of the Geological Society have been elected for the ensuing year, as follows: *President*, Prof. W. B. R. King; *Vice-Presidents*, Dr. O. M. B. Bulman, Dr. L. R. Cox, Prof. L. Hawkes and Dr. G. M. Lees; *Secretaries*, Prof. S. E. Hollingworth and Mr. A. J. Butler; *Foreign Secretary*, Prof. O. T. Jones; *Treasurer*, Mr. P. Evans; *Council*, Dr. S. Buchan, Dr. O. M. B. Bulman, Mr. A. J. Butler, Dr. G. F. Claringbull, Dr. L. R. Cox, Mr. H. G. Dines, Mr. P. Evans, Dr. W. F. Fleet, Prof. L. Hawkes, Prof. S. E. Hollingworth, Dr. R. G. S. Hudson, Prof. O. T. Jones, Prof. W. Q. Kennedy, Prof. W. B. R. King, Dr. J. F. Kirkaldy, Dr. G. M. Lees, Dr. W. A. Macfadyen, Prof. L. R. Moore, Miss H. M. Muir-Wood, Dr. J. S. Sandford, Prof. J. H. Taylor, Dr. H. D. Thomas and Dr. A. K. Wells.

The Night Sky in July

New moon occurs on July 11d. 02h. 28m., U.T., and full moon on July 26d. 12h. 20m. The following conjunctions with the moon take place: July 7d. 13h., Venus 8° S.; July 8d. 11h., Jupiter 5° S.; July 12d. 15h., Mercury 3° S.; July 19d. 01h., Saturn 8° N. At the beginning of the month Mercury sets at 21h. 30m.; but it approaches the sun too closely to be seen for the greater part of the month and is in inferior conjunction on July 25. Venus is a morning star, rising at 1h. 30m. on July 1 and about 1h. 10m. at the middle and end of the month; the visible portion of the illuminated disk varies from 0·54 to 0·67, and its stellar magnitude averages − 3·7 during the month. Mars is too close to the sun to be favourably observed. Jupiter is a morning star, rising at 2h. 05m., 1h. 20m. and 0h. 30m. on July 1, 15 and 31, respectively, and is moving eastward in the constellation Taurus. Saturn sets at 0h. 15m., 23h. 20m. and 22h. 20m. at the beginning, middle and end of the month, respectively, and is moving eastward in the constellation Virgo, stellar magnitude about 1. On July 11 there will be a partial eclipse of the sun, of greatest magnitude 0·201, but it is invisible at Greenwich. On July 26 there will be a total eclipse of the moon, also invisible at Greenwich; the beginning will be visible generally in North America, South America, Antarctica, the Pacific Ocean, Australasia and the extreme north-eastern parts of Asia, and the end generally visible in the Pacific Ocean, the north-western tip of North America, Australia, Antarctica, the Indian Ocean, and eastern and central Asia. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: July 3d. 0h. 10·8m., 22 Pisc. (*R*), and July 30d. 3h. 12·1m., λ Pisc. (*R*); *R* refers to reappearance.

Announcements

H.R.H. the Duke of Edinburgh has been pleased to accept honorary fellowship of the Institute of Welding.

The Minister of Fuel and Power has appointed Sir George Thomson to be chairman of his Scientific Advisory Council in succession to Sir Alfred Egerton, who retires at the end of June when his term of office expires. He has also appointed Mr. Kenneth Gordon, director-general of ordnance factories, Ministry of Supply, to be a member of the Council.

Dr. B. P. Uvarov, director of the Anti-Locust Research Centre, London, has been elected an honorary member of the Nederlandsche Entomologische Vereeniging, in recognition of his services to entomological science and for his contributions to the study of the Orthoptera in particular.

The following have been appointed to lectureships in the University College of North Staffordshire: Dr. D. E. Davies (physics) and Dr. A. H. Wallace (mathematics).

The annual Machinery and Implement Exhibition of the Sports Turf Research Institute (Bingley, Yorks) will be held on the sports grounds of Lever Bros., Port Sunlight, Wirrall, Cheshire, during July 1–2. A wide range of modern turf machinery, implements and ancillary equipment will be shown, as well as a display illustrating the scientific and educational work of the Institute. The Exhibition is only open to affiliated clubs and subscribers to the Institute.

The thirtieth meeting of the Australian and New Zealand Association for the Advancement of Science is to be held in Canberra, during January 13–20, 1954. Further information can be obtained from the Association, Science House, 157 Gloucester Street, Sydney, New South Wales, or from Dr. C. Barnard, honorary local secretary of the Association, Box 109, City, Canberra, A.C.T., Australia.

The Society for Experimental Biology is holding a symposium on "Active Transport" at Bangor, Caernarvonshire, during July 13–17. The speakers will include: Th. Rosenberg, H. Davson, J. A. Ramsay, J. R. Robinson, J. A. Kitching, D. C. Spanner, J. W. L. Beament, E. F. Gale, W. Wilbrandt, P. G. LeFevre, A. Rothstein, A. C. Frazer, F. W. R. Brambell, W. A. Hemmings, M. Maizels, E. J. Harris, J. F. Sutcliffe, H. Lundegårdh, R. Scott Russell, F. C. Steward, H. H. Ussing, R. D. Keynes, A. L. Hodgkin, E. J. Conway, R. E. Davies, H. B. Steinbach, J. F. Danielli. Those wishing to attend should write to Dr. D. J. Crisp, Marine Biological Station, University College of North Wales, Bangor, Caerns.

The following conferences in physics have been arranged in England in the week following the meeting in London during July 8–9, 1954, of the General Assembly of the International Union of Physics: a conference on experimental and theoretical nuclear physics during July 13–17, 1954, in the University of Glasgow; a conference on the physics of the solid state, with special reference to defects in solids, during July 13–17, 1954, in the University of Bristol. Both conferences are arranged in co-operation with the International Union of Physics. Further information will be published in due course.

The Textile Institute is offering a bursary, of value £450, tenable at the Massachusetts Institute of Technology, for nine months from September next until May 1954. The bursary, offered under the terms of the Frank Wright Memorial Fund, is open to associates of the Institute of British nationality, and is intended to enable the successful candidate to undertake a broad programme of study and research into problems concerning cotton spinning, doubling and twisting. Particulars can be obtained from the General Secretary, Textile Institute, 10 Blackfriars Street, Manchester 3; completed applications must be received by July 9.

PHOTOGRAPHIC SCIENCE AND TECHNIQUE

A CONFERENCE on photographic science and technique was held by the Scientific and Technical Group of the Royal Photographic Society on May 16 in the Arthur Worthington Hall of the University of Manchester. Dr. G. N. Burkhardt (Department of Chemistry, University of Manchester) opened the proceedings, and the chairmen of the morning and afternoon sessions were Mr. V. Gallafent (Scientific and Technical Group of the Royal Photographic Society) and Mr. C. W. Bradley (British Cotton Industry Research Association). The success of the conference was attributable in a large measure to the contributions from the Manchester area, and the self-restraint of speakers in keeping to their allotted times.

The first paper was not directly related to photography, but dealt with the legibility of print when projected from 3¼-in. square lantern slides. This clearly is a matter of importance to audiences, particularly at scientific meetings, for as Dr. R. Ollerenshaw (Manchester Royal Infirmary) pointed out there is evidence that the average eyesight of undergraduates is inferior to that of the eighteen-year-old National Service entrants and deteriorates during university residence. Whatever the form of the lettering, the illumination of the screen should be high, the contrast between the lettering and background strong, and preferably with the letters white on black. The greatest distance at which members of the audience should be seated should be six times the width of the screen (owing to the limited acuity of the eye) and the nearest distance twice the width of the screen (otherwise a tiresome rotation of the head itself must supplement the normal movement of the eyes). The seats should be grouped within a triangle of 60° angle with its apex at the centre of the screen.

A study of type faces shows that upper-case Gill Sans Bold is best for acuity, readability and speed of reading. The italic form is useful for ordinate legends to graphs. The individual characters should be not less than 2 mm. high on the slide, and lower-case type should be used only when this condition can be met. It has been found best to do all lettering with a small printing-press, a process which is at least as quick as good stencilling. The gap between lines of type should be equal to the body height of the type, and, as far as possible, each line should carry one item of the message. Diagrams and lettering in journals and books cannot well be used for lantern slides, or vice versa.

P. C. Smethurst (Smethurst High-Light, Ltd., Bolton) discussed the use of supplementary lenses with a telecentric stop. If a positive supplementary lens is arranged so that its rear principal focus is at the front nodal point of the camera lens, all the principal rays in the object space are parallel to the axis. The photograph then displays perspective such as would be obtained if the objects photographed were at infinity, and all measures of size on it are relatively correct, whatever the distances of the objects. The same device thus avoids the necessity for exact location of objects along the axis when it is important to measure sizes. Variations in perspective are obtained by placing the supplementary lens at other positions along the axis, so that the pencil of principal rays in the object space is divergent or convergent. A double system, sometimes useful, is obtained when a supplementary lens (a telescope objective) is used in the same way on each side of a camera objective.

The illumination of deep and narrow cavities by means of a concave mirror reflecting light from a lamp set to one side was then described by F. Wardlaw (Christie Hospital, Manchester). Photographs are taken through a central aperture in the mirror, the subject being observed by means of a two-mirror periscope of which the first mirror is a thin sheet of unsilvered glass. The aberrations of a concave mirror used at an angle help to smooth out the image of the lamp filament, and for the same reason high optical quality is not necessary, but care should be taken to keep light off the front edges of the cavity by suitable focusing.

Dr. H. J. J. Braddick (Department of Physics, University of Manchester) pointed out that the photography of tracks in cloud chambers involves contradictory requirements. For example, the minimum delay between the arrival of a particle and the expansion is 10 msec. Then a period up to 250 msec. is required for the water drops to grow. The shorter this period can be, the more nearly will the water drops represent the particle track; but the longer they are allowed to grow, the brighter will the track be. It is, of course, difficult to get adequate illumination because the camera lens must be stopped down to get a fair depth of the chamber sharp in the photograph. In order to get adequate illumination, high-power flash tubes or heavily over-run tungsten lamps are used. Practical trial indicates that prolonged development increases the effective speed of the photographic material—a result which, from the discussion following the paper, was not unexpected by the photographic experts. If the inevitable delay between the arrival of a particle and the expansion is increased, and an electric field is established across the chamber, the positive and negative ions separate, forming two parallel tracks from the intensities of which the relative concentrations of ions of the two signs may be estimated. This technique is not possible with nuclear track plates.

In discussing the distortion of tracks in plates for recording nuclear particles, J. V. Major (University of Manchester) said that measurements indicate that there are two components, one centrally symmetrical and the other like a shear across the plate. Uneven drying (from the edges inwards) can account for part of the distortion, but the origin of the remainder is not clear. Temperature gradients during development may be responsible.

E. W. H. Selwyn (Kodak, Ltd.) considered progress in the physics of the developed image. Our qualitative knowledge of the make-up of the characteristic curve, of granularity, graininess, resolving power and sharpness, is fairly good, though there are still outstanding problems, and little quantitative

information is available. Fuller details are available in the *Journal of Photographic Science*, **1**, 60 (1953).

Methods of high-speed photography, based on dissection of the image, were then described by Dr. J. S. Courtney-Pratt (University of Cambridge). If a plate embossed with a large number of lenses is placed near the focal plane of a camera, a series of images of the camera lens will be formed on the sensitive material, and these taken all together form a picture of what is in front of the camera, rather like a half-tone illustration. When a small aperture is moved across the camera lens, a continuous line of overlapping small images is formed behind each element of the lenticular screen, thus recording any movement in the objects in front of the camera. In practice, a series of apertures is used, like the original Baird scanning disk for television, and each lenticular element produces a 'raster'. The fundamental advantage of this system is that the speed of the scanning disk, being simple rotation, may be made very high, and with bright enough (for example, self-luminous) subjects records may be obtained at the rate of 4 million/sec. The same system reversed may be used for 'unscrambling' in slow motion or statically. A complete description, including variations on the above principle, is given in the *Journal of Photographic Science*, **1**, 21 (1953).

C. Burns (British Iron and Steel Research Association) described how the problem of recording the very fast motion of lumps of material swirling round in the hollow just beyond the tuyères in blast furnaces was dealt with. Stereoscopic motion pictures were made using two ports into a tuyère and a mirror system to produce the necessary pairs of pictures side by side on each frame of a 16-mm. film. When the pictures are projected, individual lumps of material can be recognized, against the very heterogeneous background. The location (along the axis of the tuyère) is measured by a quadruple projector arrangement of which the movements are linked. First, the two beams of a pair are made to coincide on some fixed detail in the tuyère, one on each of the projected pictures. The other two beams are then made to cross in space at the distance of the fixed detail in question, and the second pair of beams locked to the first pair. If the first pair of beams is now made to coincide with some other detail, the second pair follows its movements and intersects in space at the original distance of the new detail.

A. J. Insall (Shell Petroleum Co., Thornton le Moors) described the functions and some of the equipment of an industrial photographic section of a laboratory. One of the most important duties of such a section is to be able to repeat record photographs exactly; for this purpose arrangements must be made to locate any object precisely, to be able to duplicate the lighting arrangements and to be able to set the camera to given conditions. Records of all these settings must be kept, for it is commonly the case that photographs (for example, of pistons) require to be repeated, for comparison to be made to detect changes, sometimes at long intervals. Artistic quality (but not the technical quality) is usually unimportant, so that for recording deposits on elements of mechanisms, for example, use may be made of completely diffused lighting. Colour photography is very useful in such cases, since the additional information (on the colour) is valuable.

LIBRARY CO-OPERATION IN GREAT BRITAIN

UNDER the title "Library Co-operation in Great Britain", the report of a critical survey of the working of the National Central Library, London, and the Regional Library Bureaux, made by Mr. R. F. Vollans, deputy city librarian of Westminster, for the joint working party of the executive committee of the National Central Library and the National Committee on Regional Library Co-operation has been published*. The working party's original terms of reference were to consider methods of dealing with areas of union cataloguing at the Regional Bureaux and at the National Central Library; means of improving the efficiency of the system and its comprehensiveness; the financial requirements for coping with the present system and sources from which money can be obtained; what would be reasonable current budgets for the bureaux if this re-organization were effected; and the relationship of the union catalogues of the bureaux and the national union catalogue of the National Central Library. In deciding that the survey should be undertaken by a single individual on its behalf, the working party extended these terms of reference and instructed Mr. Vollans to deal with the coverage by each system of the libraries within its own area, co-operation within each region, the national inter-lending system, union catalogues, the recruitment, qualifications and superannuation of bureau staff, the financing of the regions, and adult education.

In accordance with these instructions, which were further detailed, Mr. Vollans, following an admirable historical survey, reviews in successive chapters the working of the regional library systems, inter-library loan procedure, the scope of service and reasons for non-availability of books, the provision of books to adult classes, union catalogues, subject specialization, bibliographical information, staff and finance. His generous tribute to the efficiency and enthusiasm of the staffs concerned in inter-library loans and his conviction as to the importance of such work do not prevent Mr. Vollans from frank criticisms of the weaknesses or defects he has detected, whether of abuse of procedure, of inappropriate rules or woodenness or unimaginative interpretation of either rules or procedure. To the man of science the report is of interest mainly as an account of the background against which the evolution and organization of a national or regional lending library in science and technology must be considered; but the scientist who reads it may well be led also to a keener appreciation of the difficulties and waste of time which may be caused by inaccuracy or carelessness in making requests for books or periodicals.

The survey shows that all libraries appear to be playing their part in this national inter-lending service, and the small libraries appear to contribute just as much as the larger libraries; nor is it always the unduly large library system which provides the more expensive and more out-of-the-way books. Twenty-one university libraries and seventy-eight special libraries participate in the regional schemes, and these libraries lend more than they borrow, in that they have more specialized resources which would not find a place on the shelves of the ordinary public

* Library Co-operation in Great Britain: Report of the National Central Library and the Regional Library Bureaux. By Robert F. Vollans. Pp. xii+139. (London: National Central Library, 1952.) 5*s*.

library. The present regions are based on geographical considerations, and are regarded as acceptable and workable units, with the exception of the regional library bureaux of Aberystwyth and Cardiff, which, it is recommended, should be merged to form a Regional Library Bureau of Wales. Except in the London area, the report recommends that all university and special libraries located within the area of a regional library bureau should become participant members of that bureau, and the bureau should be the agency, when necessary, for forwarding applications to the National Central Library. Within the London and Home Counties area, however, university libraries should make application direct to the National Central Library in respect of inter-library loans, and special libraries remain, as at present, outlier libraries of the National Central Library, membership of the London and South-Eastern Library systems remaining restricted to the public-library authorities of the area.

As regards the suggestion that the Science Library, London, might be in a position to screen scientific and technical applications before passing them to the National Central Library, Mr. Vollans recommends no deviation from the present practice. He points out that three distinct aspects of the Science Library service should be considered here: first, the Science Library is a reference library serving some twenty-two thousand readers; second, it operates a loans requisition service for books and periodicals to firms, institutions and libraries (through the medium of the National Central Library), satisfying in 1950 more than forty thousand of 72,295 requests; and thirdly, it operates a photocopying department which last year satisfied 20,348 out of 29,660 requests. In addition, some 230 of the 1,300 corporate bodies, mostly business firms, on the loans list provide details of their own holdings for incorporation in a supplementary union catalogue at the Science Library, and through this supplementary scheme 4,799 requests were satisfied last year. At present, however, the Science Library is not in a position to supply all the books required, and, though its periodical holdings are extensive, Mr. Vollans suggests that it would be wiser in the interests of consistency if the National Central Library continued to act as the clearing-house for all national and international loans. Ultimately, however, he visualizes the National Central Library as ceasing to concern itself with British publications; and, though he gives no clear indication of his views as to the future of the Science Library or its place in the new regional system, it seems possible that the new scheme whereby the Treasury gives a grant for the purchase of extra copies of special types of books and periodicals, which could be held originally but which would be available for loan, in extension of the idea of regional reference libraries for commerce and technology, would apply to the Science Library also.

Besides current periodicals, fiction and some other categories, Mr. Vollans would exclude from inter-library lending books in print costing 25*s.* or less, so far as the National Central Library is concerned, and those costing 12*s.* 6*d.* or less from the scope of the regional bureaux. He also recommends that the National Central Library should cease to purchase books for use in the system of inter-library loans, and that it should transfer to the various local education authorities the provision of books to adult classes. Both these steps would liberate staff which could be used on other activities, particularly in bringing the present national catalogues up to date and in compiling the new foreign union catalogues which, he suggests, should be the main responsibility of the National Central Library in this field.

The survey proves that the Union Catalogue is a necessary adjunct in the nation-wide service of inter-library loans, and the duplication of entries is not as heavy as might have been expected. Mr. Vollans recommends that the existing regional and national union catalogues, as at present compiled, should only continue until an agreed specified date; after this, the regional union catalogues should contain entries for British books as they appear in the British National Bibliography notified by libraries to the Bureau, using the British National Bibliography numbers, and entries for all other books should be reported either directly on sheaves or by slips, only the latter entries being sent also to the National Central Library. The practice of producing the catalogues in sheaf form will no longer be necessary, and Mr. Vollans makes other proposals for achieving economies in procedure. Much stress is laid on the question of staff, which he regards as a decisive factor in increasing administrative efficiency and reducing the present excessive costs of the inter-library loan service. Apart from the question of qualifications and adequate salaries, he points out that seconding or the adoption of a superannuation scheme which allows interchange of staff between libraries of all kinds is essential for providing the security of tenure and overcoming the difficulty of pension rights which will otherwise hinder the recruitment of staff of the requisite experience.

As regards finance, he recommends an approach to the Treasury with the view of obtaining a grant, to be spread over three years, for the purpose of bringing the regional union catalogues up to date. If this grant is not forthcoming, it is suggested that the National Central Library should direct to the bureaux some of the money saved by discontinuing the purchase of books for its own stock and for adult classes, for the same purpose of bringing the catalogues up to date and thus enabling the National Central Library's own catalogue to be brought up to date.

In an introduction to Mr. Vollans's report, Mr. W. A. Mumford indicates that the report of the joint working party, of which he is chairman, will owe much to Mr. Vollans, although the working party is not in agreement with all the latter's findings.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

REPORT FOR 1952

THE thirty-second annual report of the British Electrical and Allied Industries Research Association (usually referred to as the Electrical Research Association) records the maintenance of the activities of the Association at a high level and their expansion in certain directions*.

At the outset, it is noted that the Association has operated this year under new terms of grant from the Department of Scientific and Industrial Research, and it was in relation to these new grant conditions

* Thirty-second Annual Report of the E.R.A. for the Period ended 31st December 1952. Pp. 162. (Leatherhead: British Electrical and Allied Industries Research Association, 1953.)

and to the projected building of new laboratories at Leatherhead that the council of the Association last year launched an appeal for an increase in members' subscriptions and for capital contributions. The response to the appeal has been very gratifying, and as a result the Department grant has not only been maintained but slightly increased. Capital contributions amounting to nearly £200,000 have already been promised, subject to the institution of building operations, and part has already been paid.

The whole range of the research activities of the Association is summarized in nineteen separate sections in the report. It is, however, a little difficult to form from the report an adequate picture of the relative scale of effort devoted to the various branches of work. Much emphasis is evidently placed, as in previous years, on the work on dielectrics; part of this work being carried on at the Association's laboratories at Perivale, and part under the extra-mural programme at the National Physical Laboratory and in the Universities of Oxford, Durham, Bristol, Liverpool and London. This research ranges from fundamental theoretical work on the physics of insulating materials to directly applicable investigations concerned with the production of stabilized capacitors. On magnetic materials, fundamental work on the production and properties of electrical sheet-steel is in progress in the laboratories of the British Iron and Steel Research Association, this work being under the control of a joint committee of this Association and the Electrical Research Association. Measurements on magnetic sheet-steel and work on permanent magnet materials are being pursued largely as extra-mural researches.

Work on circuit breakers and circuit-breaking phenomena continues at a high level, and progress is reported in multiple break switches for high voltages. The report mentions, in passing, that "This year is the 25th anniversary of the gas-blast and the 21st anniversary of the baffle side-blast switchgear inventions of Dr. Whitney and Mr. Wedmore. The vital arc-control element in most modern high-power switchgear throughout the world, embodies in whole or some essential part their ideas and inventions". A model D.C. transmission link simulating high-voltage operation is now practically complete, and it is mentioned that "On the full-scale trial scheme a specific proposal has emerged relating to the cross-Channel power link and is being considered".

The network analyser, which has been under construction for some time, has been in operation on a limited basis, and additional sections of network elements are being incorporated as components are delivered. The analyser has already proved its value in a number of researches, particularly that of re-striking transients on the 132-kV. system of the British Electricity Authority. In the field of power generation, the most important problem is to raise the working temperatures of steam turbines. Extra-mural work at the Imperial College of Science and Technology, London, includes a programme for the measurement of the properties of steam up to 6,000 lb./sq. in. and 1,400° F. Work is also in progress at the National Physical Laboratory on steels suitable for components operating at 1,100° F.

During the past few years, the Electrical Research Association has been investigating the potentialities of wind-power in the British Isles. The experimental station in Orkney has been operated but is not yet in full commission, and arrangements are in hand with the College of Aeronautics for the testing of prototype equipment. Efforts are also being directed towards the development of the fuel cell, and a new research team for work on the gas cell has been established.

In the agricultural field, the Association has met with considerable success in the development of grain-drying equipment, and further work is in hand on soil warming in open ground and on soil sterilization by *in situ* electrodes. The experimental heat pump has been in use for some time, and a direct comparison has been made between the performance of the heat pump and that of a gas boiler installation.

Mention is made of the close liaison which the Electrical Research Association maintains with the professional institutions concerned with its spheres of work. A new departure has been made in the establishment of a programme of colloquia which are held at the Association's laboratories and to which guest speakers are invited from time to time. This year, the Association has issued ninety-four reports to members. Twenty reports have been published as papers in the technical press, together with a number of articles written by members of the staff and extra-mural research workers.

SCIENCE IN GOVERNMENT SERVICES

IN a recent address to the American Chemical Society (see *Nature*, June 13, p. 1055) Dr. L. A. DuBridge, president of the California Institute of Technology, was somewhat critical of the United States Government's organization for research, and, apart from the Los Alamos Scientific Laboratory, which is operated for the Atomic Energy Commission by the University of California, expressed the opinion that the Government is not getting full value from its many existing military laboratories. Dr. O. H. Wansbrough-Jones's review of the situation in Great Britain in his William Jackson Pope Memorial Lecture, "The Scientist's Place in the Services", before the Royal Society of Arts on April 29, struck a much more confident note. He gave substantial reasons for believing that in Britain we have found means of ensuring that science, especially when devoted to defence topics, can really flourish in peace-time under government control. The position which scientists gained in the stress of war has been retained, and the scientist has now a favoured and honourable place in the Services, including the Ministry of Supply, in which he no longer has to fight for opportunities to collaborate closely with the Services in such of their problems as the scientific approach might further. He has become conscious rather of the responsibilities being imposed upon him and is wondering how far they can be discharged.

Dr. Wansbrough-Jones began by reviewing the way in which the attitude of the Services to scientific men has changed, so that in the Second World War they were no longer limited to giving the Services what they wanted rather than what the Services needed, which, as Sir Henry Tizard pointed out, is not necessarily the same thing. Apart from the influence of scientists like Tizard, Fowler and others, who had been brought intimately into the defence picture before the War, the preparation of the Technical Register and the urge to help the war effort from every scientific laboratory in the country, Dr. Wansbrough-Jones thought that there were three

main factors responsible for scientific men achieving a position in which their powers are being fully exercised. The first is the dominant position in fields of defence science that the Government Establishments have achieved. The real knowledge of radar, service communication problems, explosives and propellants and chemical warfare is to be found in the Service Establishments, and at first even the most eminent outside scientists would be able to contribute relatively few ideas. The second factor is the increasing realization that a major scientific profession exists which might have its own contribution to make in its own terms. The third and most compelling factor of all is the practical and experimental proof, well exemplified in radar, that the scientist can contribute so much in non-technical and semi-technical fields. By the end of the War, all three Services had their own operational research teams at work in the field and at various headquarters, and in the Service Ministries and at many major commands there were senior scientists, of such rank and status that they could discuss, on equal terms with senior serving officers, the Services' problems from a scientific point of view. The general programme for research and development was evolved by such joint discussions, later to be carried out by the Ministry of Supply or of Aircraft Production, and by the Royal Naval Scientific Service. The arrangement really worked very well: the great step forward was the integration of the two disciplines, service and scientific, at a high level, so that the real problems were isolated, studied by the best scientific means available, and the results checked in the field by the method of operational research.

Generous tribute was paid by Dr. Wansbrough-Jones to the contribution of the Services themselves to science: progress would not have been possible had not the technical and scientific knowledge and appreciation within the Services been greater than is commonly admitted. Moreover, since the War, the Services have also made advances in their own technical education. The old scientific isolation of the Government scientist has gone, and there is a good interchange both of people and results. Nor does Dr. Wansbrough-Jones think that a turnover of young scientific men, due to the attraction of higher salaries in industry, is a bad thing, provided it is not overdone. Many men who could command far higher salaries outside the Government service remain within it on account of the excellent facilities provided. Equipment in the Government Research Establishments is first-class, and he thought that much of the research and development carried out on behalf of the Services are also of great value to British industry as a whole and to science itself. Provided recruitment of scientific men of the right quality and the scientific education of the Services continue, he believes that the harmonious working of the Service and scientific staffs will continue, and that the best use will be made of weapons, and the very difficult task of selecting the right problems to attack will be well done. Research in these fields is admittedly expensive, and though Dr. Wansbrough-Jones agreed that the scientist working for the Services has no easy task in seeing that costs are kept down without lowering the standard of the work, he appeared to be satisfied that Great Britain is getting good value from the average cost for fully-trained research worker, scientist or engineer—an average cost materially smaller than the latest American figures.

THE CONCEPT OF PHOSPHATE BOND-ENERGY

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DURING the past twenty years, it has become apparent that phosphorylation is one of the most fundamental processes occurring in living tissue. The role in metabolism of substances which bring about phosphorylation, such as adenosine triphosphate (**ATP**), is currently interpreted in terms of concepts first elaborated by Lipmann[1], who divided biologically important phosphoric acid derivatives into two groups depending on whether their standard free energy of hydrolysis is large (*c.* − 12,000 cal. mol.$^{-1}$) or small (*c.* − 2,000 cal. mol.$^{-1}$). Compounds in the first group are said to contain an 'energy-rich' or 'high-energy' O—P or N—P bond; those in the second group an 'energy-poor' or 'low-energy' O—P or N—P bond. Cleavage of 'high-energy' bonds is imagined to liberate large amounts of free energy which may be used by the organism either to carry forward energetically unfavourable reactions or for the production of work. Catabolic processes are said to be so organized as to lead to the production of 'energy-rich' compounds (for example, phosphocreatine and phosphoarginine), which function as stores of readily available energy. Anabolic processes then proceed by utilizing this energy through the mediation of adenosine tri- and di-phosphates.

This concept of 'energy-rich' phosphate bonds (which is frequently used in its literal sense) is irreconcilable with physicochemical principles. Furthermore, since the theory is actually based on free energies of hydrolysis, the relevance of classical thermodynamics to the interpretation of the detailed mechanisms of biological systems requires scrutiny.

When separate atoms combine to form molecules, that is, when chemical bonds are formed, the total energy of the system *decreases*. The reverse process, the dissociation of a molecule into its constituent atoms, therefore requires an expenditure of energy which is referred to as the heat of atomization. For a diatomic molecule, the bond-energy of the only bond present is defined as being equal to the heat of atomization, that is,

$$\Delta H \text{ for the process } X_2 \rightarrow 2X.$$

A high bond-energy, that is, a large value for ΔH, indicates a strong bond and, conversely, a low bond-energy indicates a weak bond.

In a polyatomic molecule it is usually assumed that the bond-energy of a given bond is independent of its molecular environment[2], and that individual bond-energies are strictly additive. Bond-energies defined in this way, however, are no more than a convenient, although arbitrary, method of dividing up the total heat of atomization. A more useful quantity is the bond-dissociation energy, which is equal to the heat content change ΔH for the reaction $R:S \rightarrow R\cdot + S\cdot$, where $R\cdot$ and $S\cdot$ are free radicals or atoms. This quantity, unlike the bond-energy, depends on the molecular environment (cf. the O—H bond in HO, H_2O and H_2O_2)[3], but can be measured

for bonds in polyatomic molecules only in a few special cases and under special conditions.

However, the important point for our present discussion is that bond-energies are always *positive*, that is, energy is always required to break a chemical bond. It is impossible for any simple bond-dissociation process to be energy-producing, and the concepts of 'energy-rich' bonds and the storage of energy in bonds are physically meaningless. It must also be pointed out that even if the correctly defined bond-dissociation energies of different O—P and N—P bonds could be measured, which at present is not the case, they would not, in general, bear any simple relationship to the free energies of hydrolysis, since other quantities such as the energies of formation of new bonds, the heat of ionization and solvation of all the reactants and products and the total entropy change accompanying the reaction, are also involved.

As an example of the current literal use of the term 'phosphate bond-energy' we may quote the following extract: "The removal of the elements of water from phosphoglyceric acid results in structural alterations within the molecule. These are attended by a redistribution of the intrinsic free energy of the system leading to a 'concentration' of free energy in the neighbourhood of the phosphate radical; in other words, to the generation of a new energy-rich bond. The free energy of this new bond has been estimated at about 16,000 cal., i.e., rather more than is required to form a new bond in ATP. This new bond energy, together with the phosphate radical, is then transferred to ADP and a new molecule of ATP is thereby produced"[4]. It is clear, however, that it is impossible for energy to be stored in a bond in this way, since what is meant by a chemical bond is inseparable from the idea of energy release on its formation. Clearly it would be less misleading and more correct to avoid the terms 'energy-rich' and 'energy-poor' bonds and refer simply to high and low free energies of hydrolysis.

In discussing the real significance of the free energies of hydrolysis of biologically important phosphoric acid derivatives, it must first be emphasized that there seems to be little justification for the customary division of these free energies of hydrolysis into two sharply defined groups. Not only is there a wide scatter in the quoted values[3], but also many of them have been obtained by indirect calculations[1] the reliability of which is difficult to assess.

Considerable confusion seems to have arisen in the biochemical literature from a misunderstanding of the significance of the thermodynamic functions, heat content H and free energy G, and much of this is directly due to the use of the 'energy-rich phosphate bond' nomenclature. We shall consider some typical examples. The first concerns certain experiments by Lipmann[6], who observed that under particular conditions the condensation of amino-acids to give peptides is accompanied by the hydrolysis of adenosine triphosphate. Citing this as an example of the energy from an energy-rich bond promoting biologically important synthesis, Lipmann concludes that, since only one peptide linkage (free energy of hydrolysis *c.* − 3,000 cal.) is formed for every molecule of adenosine triphosphate hydrolysed (free energy of hydrolysis *c.* − 12,000 cal.), the utilization of the phosphate bond-energy is only 25 per cent, the remainder (that is, −9,000 cal.) being 'spilled over' and dissipated as heat. Let us examine the real significance of these figures. The two free energies of hydrolysis quoted are, in fact, standard free energy changes, and from these, assuming for the purposes of this discussion that they are correct, can be calculated the standard free energy change associated with the overall reaction (*c.* − 9,000 cal.). This will not in general be equal to the actual free energy change ΔG associated with the reaction as it occurs in an organism, because this quantity is dependent on the concentrations or, more correctly, on the activities of the reactants and products, and is related to the standard free energy change ΔG^0 (reactants and products in their standard states) by the relation

$$\Delta G = \Delta G^0 + RT \log J,$$

where

$$J = \frac{(a_M)^M (a_N)^N \ldots}{(a_B)^b (a_C)^c \ldots}$$

for the general reaction

$$bB + cC + \ldots = mM + nN + \ldots$$

where a_b is the activity of B, etc.

In any event, even if the actual free energy change were − 9,000 cal., the heat of reaction would in general have a different value. If the reaction occurs under such conditions that the only work done is work of expansion against a constant pressure, then the heat absorbed will be given by the heat content change ΔH, but not by the free energy change ΔG. Unless the entropy change ΔS is zero, these two quantities will have different magnitudes and may even be of opposite sign. In the more general case where other forms of work than expansion against a constant pressure are done, the heat absorbed will not be given by the heat content change but will depend on the reaction path. Clearly it is incorrect to conclude that the standard free energy change of − 9,000 cal. for this reaction corresponds to the heat liberated, or that it is the actual free energy change associated with the reaction as it occurs in a biological environment. It is difficult to attach any meaning to the statement that the efficiency of utilization of phosphate bond-energy is only 25 per cent. This implies that the reaction might in principle be carried out with a much smaller free energy decrease. However, a different free energy change will only be possible if the reaction has a different stoichiometry and therefore a different mechanism. Whether or not such an alternative process would be possible under any given conditions can only be decided by kinetic and not by thermodynamic considerations.

Some of the confusion in the use of the thermodynamic function G can undoubtedly be attributed to its rather misleading name, free energy, which has led to it being erroneously identified with the energy function E. For example, some authors appear to think, possibly because free energy changes are usually expressed in calorie units, that the free energy change associated with a chemical reaction must in some way 'appear' either as work or as heat liberated or as both. The standard free energy change of a chemical reaction ΔG^0 is probably best thought of as a disguised equilibrium constant, the two quantities being related by the expression:

$$-\Delta G^0 = RT \log_e K.$$

Since, in the case we are considering, the standard free energy change for the overall reaction is − 9,000 cal., we may conclude that the position of equilibrium lies well over on the side of the products. However,

in deciding whether or not a reaction will, in fact, proceed under any given conditions, thermodynamic considerations are largely irrelevant. Thus, although the position of equilibrium of a reaction may be very favourable, it will only proceed if it has a sufficiently low activation energy; this is not related to the free energy change and will, for example, be considerably influenced by the presence of catalysts. If a reaction has a positive standard free energy change, that is, if the position of the equilibrium is unfavourable, it may still proceed readily if the concentrations (or activities) of the products are kept very small[7]. This may occur, for example, if the reaction is followed by another very fast reaction which removes the products as soon as they are formed, or if they are removed by diffusion through a membrane, or in any of many other possible ways.

It is difficult to understand why it should be considered on the basis of thermodynamic considerations alone that a substance such as adenosine triphosphate, which is said to contain an 'energy-rich' phosphate bond, is necessary to promote the synthesis of a peptide linkage when it is evident that any phosphate with a free energy of hydrolysis more negative than − 3,000 cal. would give an overall reaction with a negative free energy change, that is, with a favourable position of equilibrium. Although thermodynamics shows that the position of equilibrium in the supposed synthesis of a peptide linkage by adenosine triphosphate lies well over on the side of the products, it does not, and in fact cannot, tell us why adenosine triphosphate is particularly effective in this reaction. The reason for this must be sought in terms of kinetic rather than thermodynamic considerations.

Among other types of reactions which should be considered in kinetic rather than in thermodynamic terms is, for example, the enzyme-catalysed transphosphorylation of glycerol by glucose-1-phosphate. In this system, in the absence of the acceptor molecule, the enzyme causes rapid hydrolysis of the glucose-1-phosphate. To quote: "It might have been anticipated, therefore, that hydrolysis rather than transfer, would always occur in the presence of a transferring phosphatase. Apparently, however, the available free energy is not lost all at once; rather does it seem that free energy tends when possible to escape in stages"[8]. Presumably the true explanation here is that the rate of phosphorylation of glycerol by glucose-1-phosphate is greater than the rate of hydrolysis of the latter. To explain the phenomena in terms of a hypothetical desire of free energy to escape in small amounts is a necessarily sterile approach and can contribute nothing to a real understanding of the reaction.

It is often stated that the synthesis of adenosine triphosphate from adenosine diphosphate, which is associated with a standard free energy change of approximately − 12,000 cal., must be coupled with another reaction, which is said to drive the adenosine triphosphate synthesis, for which the standard free energy change is negative and numerically equal to or greater than 12,000 cal. Any difference between the two values is said to be dissipated as heat. It should be clear from the preceding discussion that the synthesis of adenosine triphosphate from the diphosphate does not require immediate coupling of this reaction with another having a greater negative standard free energy change; but rather must the activities of all the reactants and products be such that the movement of the system towards equilibrium will cause the reaction to occur, and that suitable catalysts must also be present so that paths are open by which the reaction can proceed sufficiently rapidly. It will obviously lead to incorrect conclusions if one attempts, as is often done, to link the synthesis of adenosine triphosphate with only those reactions which have a sufficiently large negative free energy change. For example, it has been concluded that, since the standard free energy change accompanying the oxidation of β-hydroxybutyrate by diphosphopyridine nucleotide is of the order of 1,000 cal., phosphorylation of adenosine diphosphate to the triphosphate cannot occur simultaneously with the former reaction. In fact, this may not be the case. The standard free energy change, and indeed thermodynamics in general, gives little information on this point.

In conclusion, we should like to stress the present need for a kinetic approach to the whole problem of phosphorylation reactions. It is clear that substances such as adenosine triphosphate are able to induce phosphorylation rapidly and selectively under a wide variety of conditions. The mechanisms by which these processes occur appear to be largely unknown. It is, however, by the study of these mechanisms, particularly in relation to the enzymes involved, and not by the invention of fictitious kinds of bond-energy, that the role of adenosine triphosphate in phosphorylation reactions will be understood.

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β-FORMS OF FIBROUS PROTEINS AND SYNTHETIC POLYPEPTIDES

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We have recently examined the X-ray reflexions from the shorter spacings in some synthetic polypeptides and fibrous proteins, with the view of determining as accurately as possible the axial repeat distance, particularly for the extended polypeptide configuration.

Silk suture or a bunch of fibres from *Bombyx mori* photographed with a cylindrical camera with the fibres horizontal and tilted at about 42° to the X-ray beam gives a diagram in which there is an exceedingly strong arc corresponding to a spacing of 1·156 A. in the direction of the fibre axis. This is probably similar in origin to the 1·2 A. reflexion which Bunn and Garner[1] found by the same technique in oriented fibres of nylon 66, and owes its intensity to the approximately constant succession of scattering

atoms along the extended chain. It is the sixth order of the axial repeat in silk (7·04 A. according to McNicholas[3]). On this basis, a more accurate value of the axial repeat is obtained from the 1·156 A. spacing than from other reflexions on layer lines. We consider, therefore, that the best value for the *c*-axis in our specimens is $6 \times 1{\cdot}156 = 6{\cdot}94$ A. For tussah silk the corresponding reflexion is at 1·153 A., which gives a *c*-axis repeat of 6·92 A.

The 1·156 A. reflexion should be characteristic of all extended or nearly extended polypeptide chains, and we accordingly looked for it in swan quill and in steam-stretched bristle and hair and in several synthetic polypeptides in the β-configuration. The expected reflexion, weaker relatively than in silk, was found in stretched pig bristle at 1·104 A., giving an axial repeat of 6·62 A. in agreement with Astbury and Street's value for stretched hair[3]. A somewhat diffuse reflexion was observed in stretched horse hair, corresponding to the same spacing. However, no indication whatever of the 1·1 A. reflexion in swan quill (or of one at 1·5 A.) was found on heavily exposed photographs taken under similar conditions to those which showed these reflexions in other polypeptides and proteins.

The synthetic polypeptides, polyglycine, poly-L-alanine and poly-γ-methyl-L-glutamate, have given results of great interest. In poly-L-alanine (β-form) the orientation was good, and a strong meridional reflexion appeared corresponding to 1·147 A. The *c*-axis repeat for poly-L-alanine is therefore 6·88 A. In polyglycine the orientation was insufficient to show whether the reflexion at 1·16 A. was on or near the meridian, but we consider this very likely in view of the almost identical meridional 1·156 A. spacing in silk. In the β-form of poly-γ-methyl-L-glutamate a meridional reflexion at 1·138 A. was found, giving a *c*-axis repeat of 6·83 A. The values of the *c*-axis repeats for the various polypeptides and proteins are collected in the accompanying table, which also gives the mean residue weights.

Material	*c*-Axis (A.)	Mean residue weight
Polyglycine	6·96–7·05	57
Poly-L-alanine (β-form)	6·88	71
Poly-γ-methyl-L-glutamate (β-form)	6·83	143
Silk (*Bombyx*)	6·94	77
Silk (tussah)	6·92	*
Pig-bristle (stretched)	6·62	107–116
Swan quill	6·2 (?)	*

* The mean residue weights do not appear to be known accurately; that of tussah silk is probably not very different from that of *Bombyx*, while that of swan quill is probably similar to that of wool (*c.* 110)

Calculations show that for a fully extended polyglycine chain the (006) reflexion has a large structure factor; consequently a strong reflexion on or near the meridian at about 1·2 A. should appear. The 1·16 A. reflexion is the only one in this region which we have observed. If the 1·16 A. reflexion in polyglycine is near the meridian, consideration of possible unit-cell structures strongly suggests that the *c*-axis has a length between 6·96 A. and 7·05 A. The latter figure corresponds to the maximum stagger between neighbouring chains, leading to a triclinic cell, and the lower figure is for a cell the base of which is normal to the chain axis (this appears to be the case in silk and in poly-L-alanine). If we assume that the chain of polyglycine is fully extended (and hitherto no reasons have been advanced against this assumption), it follows that a fully extended polypeptide chain should have an axial repeat of 6·96–7·05 A., about 4 per cent less than the value 7·23 A. based on measurements on small peptides[4]. An alternative explanation of our results is that the crystallites of polyglycine are composed of *parallel* rather than the conventional anti-parallel, polypeptide chains. In order to form satisfactory hydrogen bonds the chains (assumed in this explanation to have a repeat of 7·23 A. when fully extended) may have to contract so that their identity period becomes about 7 A. or less. We might expect, however, that this arrangement is less stable than the fully extended anti-parallel one, since the full contribution from the 'staggering' of single bonds around Cα is not obtained. A partially collapsed anti-parallel chain configuration is also a possibility, but seems open to the same objection.

Pauling and Corey[5] have stated their view that polypeptide chains will take up specific configurations corresponding to minimum energy of the chain. The fully extended chain is one such configuration; if this has a repeat length of 7·23 A. the next stable configuration (the pleated sheet) has a repeat of 6·68 A., and configurations of intermediate repeat length should be unstable. This point of view, however, does not take any account of energy from interchain forces other than those involved in hydrogen bonds.

If a fully extended polypeptide has a repeat of about 7 A., the next stable configuration should have a repeat about 6·4 A. It is quite certain that poly-L-alanine (which according to Pauling and Corey should form a pleated sheet by reason of steric hindrance of the methyl groups) has a *c*-axis repeat of 6·88 A. (or a multiple of this), and cannot therefore take up the pleated-sheet configuration. The small contraction compared with polyglycine suggests that steric hindrance is accommodated, but that no contraction to a specific configuration (involving staggering of single bonds around the Cα atoms) takes place. This may mean that the effect of methyl-group steric hindrance has been over-estimated by Pauling and Corey, and also that the energy of the whole crystalline system may be at a minimum even though the individual chains are not in the position of lowest energy. The alanine content of tussah silk is reported to be higher than that of *Bombyx mori*, and it is therefore interesting to note that the *c*-axis repeat in tussah is intermediate between that of poly-L-alanine and *Bombyx*.

The result obtained with swan quill is surprising. This material shows infra-red dichroism of the type associated with a β polypeptide[6], but very much less marked than in silk. It might be thought that part of the structure consisted of α-chains at right angles to the fibre axis, but we have been unable to detect a 1·5 A. reflexion either on the meridian or the equator. The large number of sharp reflexions in the centre of the diagram (similar to sea-gull quill[7]) shows that parts of the structure are highly oriented. If the 3·1 A. meridional reflexion in swan quill indicates a unit cell with $c = 6{\cdot}2$ A., then calculation shows that the 1·03 A. reflexion in such a contracted structure would be weak. This may perhaps explain our failure to observe such a reflexion. If this explanation be correct, it furnishes some evidence for planar or nearly planar amide groups in feather keratin, for the low calculated intensity of the 1·1 A. reflexion for a slightly contracted chain is a result of rotation assumed to be around the Cα single bonds only. The effect of this rotation is to destroy the

approximately equal succession along the chain axis of atoms in the backbone.

The table shows that the fibre repeat-distances in the β-forms of the synthetic polypeptides and in the silks are surprisingly similar considering the wide variations in the size of the side chains. Such variations as are found may be attributed to the presence or absence of a β-carbon atom, rather than to the total bulk of the side chains. It is therefore surprising that the *c*-axis repeats of the β-keratins are so much smaller, and we conclude that the character of the side chains is more important in this respect than their mere size.

In conclusion, we consider that the observations briefly set out above suggest that we are not yet in a position to calculate with precision the arrangement of the polypeptide backbone of these large molecules. If this is the case when we are concerned with regions of high crystallinity, it is still more true of the amorphous parts which make up by far the greater part of many fibrous proteins, and of all proteins in solution. [March 24.

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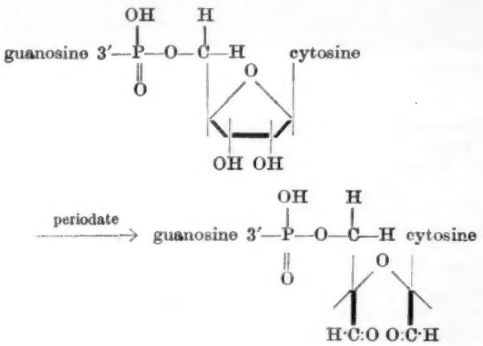
NATURAL CONFIGURATION OF THE PURINE NUCLEOTIDES IN RIBONUCLEIC ACIDS

Chemical Hydrolysis of the Dinucleoside Phosphates

WHEN hydrolysed by means of cold alkali or acid, the ribonucleic acids give rise to mixtures of isomeric nucleotides, the *a* and *b* nucleotides of Carter[1] and Cohn[2], which are the 2′- and 3′-phosphates of the four nucleosides, probably in that order which we shall assume for convenience. In the intact nucleic acids, these substances are linked to each other largely or possibly entirely by phosphate diester bridges also involving the 5′ OH group in the nucleosides. It is known, however, that acid or alkaline hydrolysis effects the degradation of ribonucleic acid through intermediate cyclic phosphate compounds involving both the 2′- and 3′-positions in the nucleoside residues[3,4], so that the final position of the phosphate residue in the nucleotide liberated is no certain guide to its position in the intact nucleic acid. Similarly, in ribonuclease digestion, the fact that the pyrimidine nucleotides liberated are all of the *b* (3′)-type[5] is not definite proof that the 3′-link is involved in the intact nucleic acid, because the enzymic degradation also goes through a cyclic step and so phosphate migration may also take place in this case.

The original object of this work was to degrade relatively simple compounds derived from ribonucleic acid in order to determine the actual configuration in the internucleotide link, and the dinucleotides resulting from exhaustive ribonuclease digestion[6] seemed to be the most profitable substances to investigate. These are composed of a purine nucleoside joined at C 2′ or 3′ by a phosphate diester bridge to the 5′-group of a pyrimidine nucleoside 3′-phosphate. This type of compound is resistant to snake venom phosphodiesterase, but if the pyrimidine nucleotide residue is dephosphorylated at C 3′, this enzyme then breaks the resulting dinucleoside monophosphate to give a pyrimidine nucleoside 5′-phosphate and a purine nucleoside. Our aim was to attempt to induce the enzyme to break the other end of the phosphate bridge, so as to leave the phosphoric acid joined either at C 2′ or C 3′ without the intervention of a cyclic intermediate. At this point we should state that we did not succeed in this object, but instead we discovered a chemical method for accomplishing this degradation.

As an example of this degradation we shall take the case of the dinucleotide of guanine and cytosine. This was dephosphorylated by prostate phosphomonoesterase to give a dinucleoside monophosphate.



On treatment with sodium periodate, the cytidine residue was split between C 2′ and C 3′ to give a dialdehyde derivative. This substance may be isolated from excess periodate and iodate by chromatography in *iso*propanol – ammonia[4].

When treated at *p*H 10 with Russell viper venom for 6 hr. at 37° C. and rechromatographed in the same solvent, two substances were detected. The one with the higher R_F value was eluted and found to have an absorption spectrum similar to, but not identical with, that of cytosine. The slower-moving compound, which had the same R_F as guanylic acid, was eluted, and on chromatographing in an ammonium sulphate – sodium acetate – *iso*propanol – water solvent[4] was found to be guanylic acid *b* exclusively, and its identity was confirmed by an examination of its absorption spectrum.

Control experiments, however, gave the same result; that is, it was possible to obtain guanylic acid *b*, together with the cytosine-containing compound (which, incidentally, does not seem to be identical with the substance obtained by the action of periodate on cytidine), from the dialdehyde derivative of the dinucleoside monophosphate of guanine and cytosine without the addition of snake venom, but simply by incubation at *p*H 10. Further experiments confirmed that this action was independent of a diesterase and occurred under conditions in which cyclic nucleotides are completely stable. Apparently the dialdehyde derivative of a dinucleoside monophosphate is unusually unstable to alkali, and we find that a certain amount of splitting actually takes place even on chromatographing in *iso*propanol – ammonia.

This method has also been applied to the degradation of the dinucleoside monophosphates obtained from guanylyl uridylic acid, adenylyl cytidylic acid and adenylyl uridylic acid, and in each case the dialdehyde derivative yielded, on mild alkaline treatment, either guanylic acid *b* or adenylic acid *b*. Thus both purine nucleotides occur in the dinucleotides (and presumably in ribonucleic acid) as the *b* isomers, which are probably the nucleoside 3′-phosphates.

The possibilities of this procedure, by means of which the phosphate terminal nucleotide of a dinucleotide may be removed, are at once apparent. The conditions under which the experiment is carried out are so mild that any polynucleotide would be quite stable, and by a repetition of the procedure it should be possible to determine the nucleotide sequence in a polynucleotide chain. As the next step we intend to apply the method to the investigation of trinucleotides.

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Enzymatic Splitting of Purine Internucleotide Linkages

The nature of the phospho diester internucleotide linkages involving purine residues of ribonucleic acid has not been previously demonstrated. In the preceding communication, it was decided that purine nucleotides occur in ribonucleic acid as the *b* isomers. We have reached the same conclusion from enzymatic studies with a spleen fraction. Volkin and Cohn[1] had already isolated *b* nucleotides of all the bases after digestion of ribonucleic acid with a crude spleen extract[2]. However, this did not establish the position of the phosphoryl group (2′- or 3′-) in the original diester, since the occurrence of nucleoside 2′ : 3′-phosphates as intermediates was not ruled out. These cyclic compounds, if formed in the course of hydrolysis, would allow the possibility of phosphoryl migration. In the present investigation, we have found that guanylic acid *b* and adenylic acid *b* resulted from the digestion of the ribonuclease-resistant 'core' with a fraction from spleen, and no cyclic compounds were observed at any time. Furthermore, it has been shown that the cyclic mononucleotides were quite slowly attacked by the enzyme and therefore would have accumulated, had they been intermediates.

The enzyme preparation was one of several fractions previously separated from calf spleen[3]. Fresh tissue was homogenized in cold 8·5 per cent sucrose, adjusted to *p*H 5 and centrifuged. The precipitate was washed with 8·5 per cent sucrose and then with acetone (— 10°). From the dry acetone powder it was possible to extract the enzyme activity in soluble form with 0·2 *N* acetate buffer, *p*H 6. The extract was fractionated with ammonium sulphate at *p*H 5 and again at *p*H 8.

This fraction was incubated with 'core' prepared from ribonucleic acid by exhaustive digestion with ribonuclease followed by dialysis against tap water. Both yeast and turnip yellow mosaic virus were used as sources of ribonucleic acid. At least 90 per cent of the purine residues of 'core' were liberated as *b* nucleotides, as determined by paper chromatography[4]. No cyclic intermediates were found at any time during the digestion.

Now it was necessary to establish that our failure to observe cyclic mononucleotides was not due to their being rapidly hydrolysed. Accordingly, we compared the rate of formation of purine mononucleotides from 'core' with the rate of hydrolysis of cyclic guanylic and adenylic acids. The incubations were carried out at 37° in a total volume of 1 ml., containing 80 μmoles of potassium phosphate buffer, *p*H 7·4, 0·3 mgm. of spleen fraction and substrate. As an example, 9·6 μmoles of guanylic acid *b* were derived from 5 mgm. of 'core' in 1 hr. During this time, 1·8 μmoles of guanosine 2′ : 3′-phosphate were hydrolysed to the extent of only 16 per cent, and 0·3 μmole was split to the extent of 70 per cent. Clearly, the guanylic acid was not formed by way of guanosine 2′ : 3′-phosphate. Under these conditions, the cyclic compound would be expected to accumulate because of its slow rate of hydrolysis, but none was detected. In parallel experiments 0·3 and 0·6 μmole of guanosine 2′ : 3′-phosphate was actually added to a mixture of 'core' and enzyme. Hydrolysis of 'core' proceeded, and most of the added cyclic compound survived an hour's incubation. Cyclic adenylic acid was somewhat more rapidly split by the spleen preparation, but its accumulation could also be expected, had it been formed as an intermediate.

Similar observations were made with the dinucleotides of guanine and cytosine, guanine and uracil, adenine and uracil, and adenine and cytosine. Preparation of these compounds is described elsewhere[5]. All were split to give *b* nucleotides of purine bases, without the appearance of cyclic mononucleotides. Again, as an example, 1·25 μmoles of the dinucleotide of guanine and cytosine were hydrolysed to the extent of 85 per cent in 1 hr., with no accumulation of guanosine 2′ : 3′-phosphate. Under similar conditions, 1·3 μmoles of guanosine 2′ : 3′-phosphate were incubated with spleen fraction and 50 per cent still remained after 3 hr.

From these findings we conclude that the purine nucleotide residues in ribonucleic acid occur largely in the *b* form.

One of us (L. A. H.) is on leave from the National Institutes of Health, Bethesda, Maryland.

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LETTERS TO THE EDITORS

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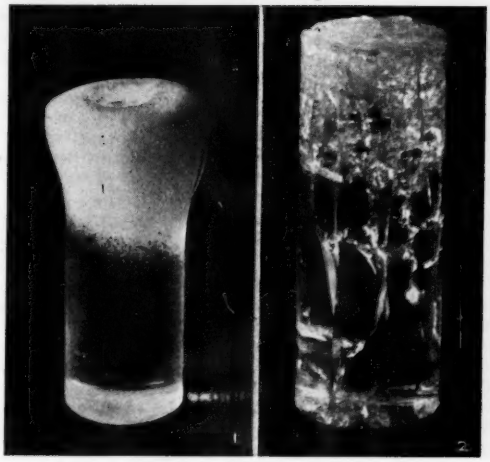
Breakdown of Methyl Methacrylate Polymer by High-Energy Radiation

THE behaviour of polymethyl methacrylate ('Perspex') when exposed to high energy radiation is markedly different from that of many other long-chain polymers such as 'Polythene' and polystyrene[1]. These latter develop cross-links forming a thermo-setting material, whereas polymethyl methacrylate shows rapid breakdown after relatively short radiation doses. The nature of the changes produced is complex, and appears to vary with the temperature as well as the radiation dose.

Most of the irradiation work was carried out in the BEPO atomic pile at Harwell, at a temperature of about 70° C. Unit radiation dose is defined as a flux of 10^{17} slow neutron/cm.^{2} plus the associated fast neutrons and gamma-rays. After exposure to some two units of radiation 'Perspex' loses its transparent appearance, expands and forms a white brittle material, consisting of a mass of bubbles. Higher radiation doses produce a white powder. If shorter radiation doses are given, there is no obvious change in the 'Perspex', apart from a yellowish tint which occurs in many organic compounds exposed in the pile. When these specimens are afterwards heated, internal bubbling occurs and the material expands to six to eight times its original volume. The temperature at which this change occurs is determined by the radiation dose—the nearer the radiation dose approaches 2 units, the lower the subsequent temperature needed to produce bubbling. Thus a radiation dose of only 0·1 unit is needed for bubbling to occur at a temperature of 140° C. This phenomenon is ascribed to the breakdown of the side-chains, releasing mainly carbon monoxide and dioxide and hydrogen. These are maintained under pressure inside the material until the temperature rise weakens the material sufficiently to allow bubbles to form.

An interesting observation is that bubbling does not occur within a distance of about 1 mm. from the free surface of a specimen. In this region 'Perspex' remains transparent, and tough. The expanded material therefore consists of an internal network of bubbled material surrounded by a thin and tougher coat. To explain the losses of weight observed in 'Polythene' on irradiation[2], it was necessary to assume that certain gases produced by radiation can only escape from the polymer if they are liberated within a small distance from the surface. In the present work on polymethyl methacrylate, this assumption has been justified. Thus a specimen irradiated for 1·1 units, and afterwards heated for a short time to produce a small amount of bubbling, had a 'free zone' (without bubbles) about 1 mm. in thickness and following the surface contours. This free zone is not due to some form of low-penetrating radiation nor to the presence of oxygen. The assumption of diffusion over a limited distance must therefore be accepted.

The same effect has been produced by irradiation with pure gamma-radiation from a cobalt-60 source. Fig. 1 shows a rod of 'Perspex', irradiated in a non-uniform γ-flux, and afterwards heated to produce bubbling. The end of the rod subjected to the highest



radiation dose shows considerable expansion, whereas the opposite end is apparently unaffected. If the radiation takes place at 20° C., considerable doses can be absorbed without any obvious effects on the specimen. If it is then left standing for several months, intense cracking appears in the specimen, but no bubbling (Fig. 2). It would therefore appear that temperature above the second-order transition is needed for large-scale gas diffusion to take place.

One may perhaps envisage irradiated 'Perspex' being used as a heat-insulating material. Small blocks of the polymer can be placed inside a vessel and, by heating, expanded *in situ* to give a bubbled material filling the required volume.

Fuller details will be published elsewhere[3].

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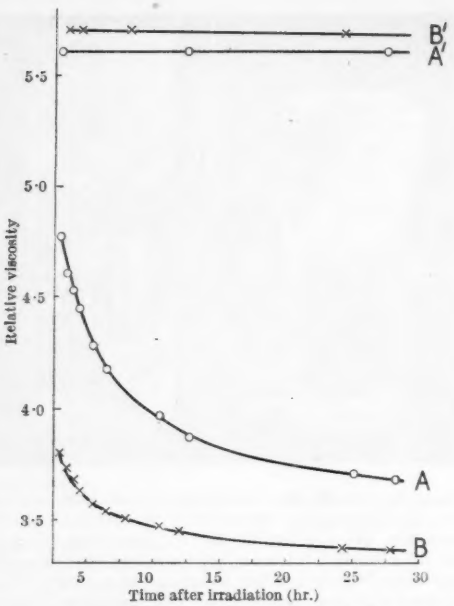
'After-effect' in Aqueous Solutions of Deoxyribonucleic Acid irradiated with X-Rays

IT has been known for some time that the irradiation of aqueous solutions of deoxyribonucleic acid with X-rays leads to a loss of viscosity[1]. However, apart from any drop in viscosity during the irradiation, it has been observed by several workers[1,2] that there is also an 'after-effect' in these solutions, namely, a slow decrease of viscosity which continues for some time after the actual irradiation.

Although recent work[3] has to a large extent clarified the nature of this after-effect, a certain amount of confusion still exists with regard to its extent under different experimental conditions. Butler and Conway[2] have stated that the after-effect is only observed when molecular oxygen is present in the solution during the irradiation, and they have suggested that the effect is due to a slow decomposition of a peroxidic derivative of the deoxyribonucleic acid which is formed by the HO_2 radicals present under these conditions. At first these authors concluded that the substance formed was similar to a dialkyl-peroxide. However, in a subsequent



Change of viscosity of 0·1 per cent aqueous solutions of thymus deoxyribonucleic acid (Signer) after irradiation with X-rays (200 kV.). Total dose, 6,000 rep. (dose rate, 1,000 rep./min.). Curve *A*, Irradiation in the presence of atmospheric oxygen; curve *B*, irradiation *in vacuo*. *A′* and *B′* refer to the corresponding unirradiated control solutions

publication[4] they reported the presence of hydrogen peroxide and suggested that hydroperoxides were formed by the reaction between deoxyribonucleic acid and HO_2 radicals and that the latter are solely responsible for the after-effect.

Contrary to this view, we have always considered that the after-effect in deoxyribonucleic acid solutions is due to a slow hydrolysis of labile substances (for example, labile phosphate esters) which are formed from the deoxyribonucleic acid, particularly by the oxidizing radicals produced in the irradiation process. However, on this basis it would be difficult to understand that the after-effect should only occur in the presence of molecular oxygen, because it is well known[5] that (oxidizing) OH radicals are also present in evacuated solutions, as they are formed by the action of the ionizing radiation on water (equation 1).

We have therefore irradiated deoxyribonucleic acid solutions, under oxygen-free conditions, and have, in fact, observed a definite after-effect on the viscosity. The accompanying graph shows the results obtained for a highly polymerized 'Signer' deoxyribonucleic acid specimen, relative viscosities being determined in an Ostwald viscometer; very similar results were obtained with a number of different samples of nucleate.

In all cases the after-effect *in vacuo* was about one-third of that obtained in the presence of oxygen. Thus, the effect of oxygen is only one of enhancement, and this observation is in complete agreement with experiments on a number of other substances[6] (for example, the formation of acetaldehyde from alcohol, of pyruvic acid from lactic acid and from alanine, etc.), where the ratios of the yields in the absence and presence of oxygen were always found to be between one-third and one-sixth, depending on the substances and on the experimental conditions.

In general, the reaction, in the absence of molecular oxygen, can be explained by the following mechanism (RH = solute):

Primary radiation process[6]: $H_2O \longrightarrow\!\!\!\!\sim\!\!\!\!\rightarrow H + OH$ (1)

$$RH + OH \rightarrow R^{\cdot} + H_2O \quad (2a)$$

$$R^{\cdot} + OH \rightarrow \text{product} \quad (2b)$$

Back reactions:

$$H + OH \rightarrow H_2O \quad (3)$$

$$R^{\cdot} + H \rightarrow RH \quad (4)$$

In the presence of molecular oxygen, however, one will have the reactions:

$$H + O_2 \rightarrow HO_2 \quad (5)$$

and

$$R^{\cdot} + O_2 \rightarrow RO_2^{\cdot} \rightarrow RO_2H \rightarrow \text{product} \quad (6)$$

Thus the back reactions (3) and (4) may be largely inhibited, leading to an increased yield.

It is therefore clear from the reactions outlined above that, although molecular oxygen is not a decisive factor, nevertheless its presence can enhance very considerably the attack on the nucleic acid.

Our views on the after-effect have been confirmed already to some extent by our recent experiments[7] substantiating our earlier suppositions that labile compounds are formed; we have, in fact, been able to demonstrate the presence of labile phosphate esters in irradiated nucleic acid solutions.

A full account of this work will be published elsewhere. Our thanks are due to Prof. R. Signer for supplying several samples of deoxyribonucleic acid.

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Effect of Nitric Oxide on the Thermal Decomposition of Ethyl Nitrate

We have noted with interest the recent communications of Style *et al.* regarding the reaction between diethyl peroxide and nitric oxide in the gas phase, and the inhibition of the thermal decomposition of diethyl peroxide[1]. It has been customary to assume that nitric oxide inhibits reactions in the gas phase by the removal of active free radicals with the formation of compounds of the type $R.NO$, where R is the radical. As Style points out, however, inhibition by nitric oxide may not necessarily indicate a free radical mechanism.

We have recently made observations in the course of experiments on the thermal decomposition of

ethyl nitrate[2] in the presence of nitric oxide which would tend to support this idea. During these experiments, the maximum pressure of nitrogen dioxide attained is never more than 10 per cent or so of the initial pressure of ethyl nitrate. However, if nitric oxide is present initially, the nitrogen dioxide produced is considerably increased and the time at which maximum pressure occurs is markedly reduced. This is illustrated in the accompanying table.

Pressure of ethyl nitrate (mm. Hg)	Pressure of nitric oxide (mm. Hg)	Max. pressure of nitrogen dioxide (mm. Hg)	Time of nitrogen dioxide max. (min.)
54·2	0·0	6·0	28
47·9	6·1	6·5	12
53·6	12·9	11·5	8
52·4	25·1	16·0	7

These figures are supported by gas analyses at the maxima, and calculation shows that the nitrogen dioxide could not result solely from the thermal fission of the ethyl nitrate. Hence we are led to the conclusion that nitric oxide itself reacts directly with ethyl nitrate, thus :

$$C_2H_5ONO_2 + NO \rightarrow C_2H_5ONO + NO_2 + 5 \text{ k.cal.}$$

In contrast to earlier claims[2], the initial rate of pressure increase in the experiments above is decreased by the same order of magnitude as is observed when nitrogen dioxide is added. This is to be expected, since ethyl nitrate is to some extent rapidly converted to ethyl nitrite, which is known to decompose appreciably slower in the same temperature-range, lowering the overall rate. Some independent evidence that ethyl nitrite is present comes from the work of Levy[3], who, from an infra-red examination of the products of ethyl nitrate decomposition, claims the existence of up to 70 mole per cent of ethyl nitrite.

Full details of our work will be published elsewhere; but it is clear that the above type of reaction involving nitric oxide will have importance not only in nitric ester decomposition, but also in other allied investigations.

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Oscillating Droplets

An increasing amount of work is being carried out on the behaviour of drops of solvent rising or falling in water, in order to investigate the rate-determining steps involved in solvent extraction. Previous work in these laboratories using mutually saturated phases demonstrated that in packed columns the statistical mean volume-surface diameter is proportional to $(\gamma/\Delta\rho g)^{1/2}$ when the packing size is above a critical value[1]. Later experiments have now shown that if the dispersed solvent phase contains an undistributed solute, for example, acetone, the droplets are larger than predicted, whereas no effect is observed if the solute is in the aqueous phase. A smaller increase in size is also obtained when the phases are pure but not mutually saturated.

Since the increase in size could have been caused by an increase in the interfacial tensions in these systems, measurements of the interfacial tensions were made using the pendant-drop method of Andreas *et al.*[2]. The drop was formed with a hypodermic syringe and an enlarged image was projected on to a screen; ciné-photographs were also taken. It was observed that the surfaces of the drops were invariably disturbed by rippling and the drops themselves were subjected to erratic pulsations; in addition, the change in the interfacial tension, if any, measured between pulsations, was in the wrong direction to account for the increased droplet size. It was possible to follow the flow pattern from the refraction lines, and it could be seen that the pulsations were apparently associated with 'shock waves' originating within or on the surface of the drop. These waves passed through the interface, each causing a noticeable amount of transfer. When aluminium powder was suspended in the droplets a violent circulation was seen at the surface of the drop. This behaviour also occurred when the drops were completely detached from the capillary tip and was therefore not due to diffusion of solute from the bulk of the solvent into the drop.

A further investigation of solute transfer to and from droplets was then carried out using as solutes acetone, ethyl alcohol, acetic acid, nitric acid, hydrochloric acid, ferric chloride, cobalt chloride, ceric ammonium nitrate and uranyl nitrate. As solvents, diethyl ether, benzene, toluene, ethyl acetate, methyl *i*-butyl ketone, dibutyl carbitol and nitrobenzene were used. When these solutes passed from a solvent droplet to water, oscillations of the drops were observed in every case except with uranyl nitrate. Oscillations of water droplets suspended in a solvent phase were also observed when the transfer was into the droplets. With uranyl nitrate, oscillations were only obtained when the transfer was in the reverse direction. This suggests that the phenomenon is associated with the heat evolved in transfer, since heat is absorbed when uranyl nitrate passes from a solvent phase to water, whereas heat is evolved by the other solutes. The presence of surface-active materials such as proteins and detergents reduced the effect; this may indicate that the effect of the heat of transfer is to cause local variations in the interfacial tension, thereby disturbing the equilibrium of the droplet.

No oscillations were observed when droplets of pure unsaturated solvents were suspended in water. A slight effect was observed in some cases when organic solutes passed from water to a suspended solvent drop. McBain[3] has earlier reported a somewhat similar behaviour at plane liquid–liquid interfaces, which gives rise to micro-emulsification at the interface.

The present results indicate that the non-turbulent layers adjacent to the interface, postulated by Whitman[4], may be absent in certain conditions, and that the pulsations may be more effective in promoting transfer than molecular diffusion. Since the effect varies considerably from system to system, a comparison of transfer-rates for different systems must be carried out with circumspection.

Thanks are due to Mr. A. S. White for his interest and encouragement in this work, and to the Director,

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Electronically controlled Spectrographic Spark Source

In the past two decades, various types of high-voltage spectrographic spark sources have been developed, such as the so-called uncontrolled[1], mechanically controlled[2,3], auxiliary spark gap controlled[4,5] and electronically controlled[6–8] types.

In my laboratory a new electronically controlled spectrographic spark source system has been constructed, the wiring diagram of which is shown in Fig. 1. *T* denotes a high-voltage transformer charging the condenser *C* through the vacuum diode *V2*. *G1–G2* is a twin spark gap to control the discharge of the condenser *C*.

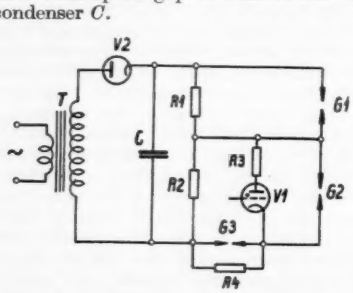

Fig. 1. Wiring diagram of the high-energy electronically controlled spark source. *C*, condenser; *G1–G2*, controlling twin spark gap; *G3*, analytical spark gap; *R1*, *R2*, *R3*, *R4*, ohmic resistors; *T*, high-voltage transformer; *V1*, gas-filled triode (thyratron); *V2*, rectifier tube

By means of resistors *R1* and *R2*, the voltage appearing on the terminals of the condenser *C* is uniformly distributed to the twin controlling spark gap *G1–G2*. *G3* is the analytical spark gap, shunted as usual by the resistor *R4*. *V1* is a gas-filled triode (thyratron) normally closed by a negative bias. The spark gaps *G1* and *G2* must be adjusted so that their breakdown is safely prevented before applying the firing pulse to the thyratron grid. The role of the ohmic resistance *R3* will be dealt with later.

The system operates in the following manner. Condenser *C* being charged to the maximum voltage produced by transformer *T* during one half-period of the A.C. voltage wave, in the following half-period a positive voltage pulse is applied to the grid of the tube *V1* closed by the negative bias, in consequence of which the tube fires. Thus, *R3* being much smaller in value than *R1* and *R2* respectively, the lower electrode of spark gap *G1* comes practically to cathode potential. As the common electrode of the twin spark gap *G1–G2* is at cathode potential, the entire charging voltage of condenser *C* appears on the electrodes of *G1*, which will break down owing to the approximately double voltage obtained. Then condenser *C* begins to discharge through *G1*, the ohmic resistors *R3* and *R4* and the tube *V1*. As *G1* is practically short-circuited owing to the breakdown previously mentioned and the resulting current flow, the greater part of the voltage on the terminals of condenser *C* appears on the terminals of *R3* and the spark gap *G2* respectively, in consequence of which the latter also fires. *R3* is assumed to be much larger in value than *R4*. After the breakdown at *G2*, the voltage on the terminals of condenser *C* appears on those of resistor *R4* and the analytical spark gap *G3* respectively, so that the latter also breaks down. Now the discharge of condenser *C* continues through *G1*, *G2* and *G3*. The spark gaps *G2* and *G3* being broken down, the voltage on the terminals of the ohmic resistor *R3* consists only of the arc voltage of *G2*, where the current flow will be quite negligible. Tube *V1* is extinguished either at the end of the discharge of condenser *C* or, if the frequency of the circuit is low, before the end of the discharge. This depends on the electrical characteristics of circuit *C–G1–G2–G3* where, according to the requirements of the analysis, a self-inductance and an ohmic resistor can also be inserted.

The positive voltage pulses necessary to control tube *V1* are supplied by means of a mechanical switch or electronically[6]. In the arrangement of Fig. 1, sparks can be produced at the rate of the mains voltage frequency or at a lower rate. Controlling the grid of *V1* by means of a pulse generator, the number of sparks per second can be any subharmonic frequency of the mains. If the circuit in Fig. 1 is appropriately adjusted, the number of discharges per second can be twice as great, or more than the frequency of the mains voltage.

While the electronically controlled spark source in Fig. 1 has been especially devised to produce high-energy sparks, the apparatus in Fig. 2 is used to provide low-voltage condensed sparks and interrupted arcs. *T*, *V2*, *V3*, *C1*, *C2* are the components of a conventional voltage doubler. Condenser *C3* producing the actual spark energy is charged through resistor *R4* from condensers *C1* and *C2*. The remaining part of the circuit is the same as that of Fig. 1, with the difference that the spark gap *G3* of Fig. 1 as well as resistor *R4* are omitted. Condenser *C* discharges through the spark gap *G1–G2* and the Tesla transformer *A*, the voltage of which ignites the interrupted arc or the low-voltage condensed spark. The grid of the thyratron tube *V1* can be controlled by any frequency desired.

More detailed descriptions of spark sources of similar design will appear elsewhere at later dates.

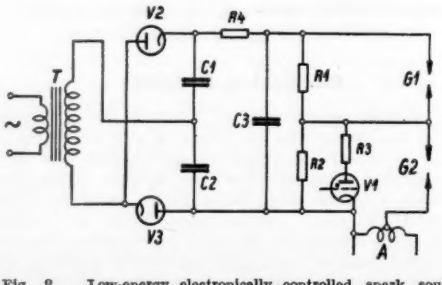

Fig. 2. Low-energy electronically controlled spark source. *A*, Tesla transformer; *C1*, *C2*, *C3*, condensers; *G1–G2*, controlling twin spark gap; *R1*, *R2*, *R3*, *R4*, ohmic resistors; *T*, transformer; *V1*, gas-filled triode (thyratron); *V2*, *V3*, rectifier tubes

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Effect of Continued Iron Administration on Growth

During studies on the effects of repeated parenteral administration of iron to mice, rabbits and guinea pigs, various toxic manifestations were observed[1]; but in general there was little effect on growth with either colloidal or diffusible forms of iron. One diffusible iron preparation, namely, 'ferric hydroxide ferrous ascorbate', however, depressed growth markedly. The results obtained with three iron preparations are summarized below.

(*a*) *Colloidal iron.* When iron in colloidal form is given in repeated sub-lethal doses, a large quantity may accumulate in the body before serious harm results. Mice lived two to three months after twelve weekly intravenous doses of 180 mgm. iron per kgm. of saccharated iron oxide, that is, a total dose of 2·16 gm. iron/kgm. There was no loss of weight in these animals until death supervened. The ultimate cause of death is not clear; but severe damage was noted in the lungs, liver and kidneys. Four one-week old mice injected daily with 40 mgm. iron/kgm. of saccharated iron oxide by the subcutaneous route gained weight normally until they reached adult size (seven weeks), the total dose given being 0·9 gm. iron/kgm. of their final body-weight (20 gm.). Two three-day-old guinea pigs injected daily with 40 mgm. iron/kgm. of the same preparation subcutaneously also continued to gain weight much the same as two control guinea pigs.

(*b*) *Diffusible iron.* Diffusible iron preparations behave differently both as regards toxicity and fate in the body, the results obtained depending on the nature of the non-ionized whole molecule of the iron compound[1,2]. Seven young guinea pigs, varying in age from two days to a few weeks and in weight from 75 to 320 gm., were given large doses of diffusible preparations of iron by repeated subcutaneous injections. Four of these received 11·25 mgm. iron/kgm. daily in the form of 'ferric hydroxide ferrous ascorbate', while the remaining three had 30 mgm. iron/kgm. daily in the form of 'ferric chloride caramelate'[1]. The latter group grew and gained weight without obvious deviation from the normal, during the whole period of the injections which lasted 63 days, their final weights being 496, 450 and 465 gm. The first four, however, died after 17, 27, 43 and 63 days respectively. Their growth was interfered with appreciably, and although they continued to increase in weight for a while, the rate of increase soon slowed down. In the case of guinea pigs 3 and 4, serious loss of weight was noted in the last few weeks of life, their final weights being 180 and 175 gm. There were hæmorrhages in the lungs and histological damage in the adrenals in all four guinea pigs.

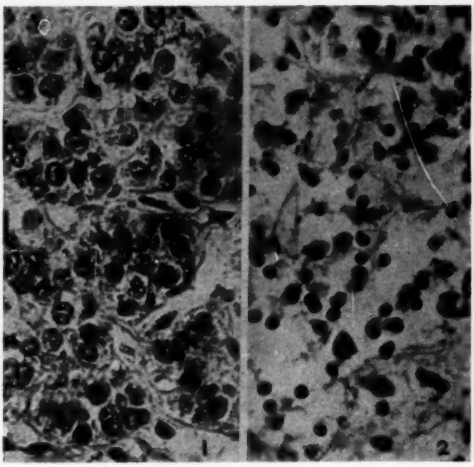

Fig. 1. Anterior pituitary of normal guinea pig showing large vesicular nuclei and abundant cytoplasm. Stained with carmalum. × 500

Fig. 2. Anterior pituitary of guinea pig 4, injected with 'ferric hydroxide ferrous ascorbate'. Section shows numerous pyknotic nuclei and wide spaces between atrophied cytoplasm of cells. Stained with carmalum. × 500

Growth retardation after injections of 'ferric hydroxide ferrous ascorbate' may be secondary to adrenal and lung damage, and could be caused through interference with the normal functioning of ascorbic acid. On the other hand, a direct interference with the functions of the pituitary seems likely. Sections of the pituitary in guinea pig 4 revealed iron staining in the cells of the anterior pituitary—a finding which is recorded in the experimental animal for the first time—and there was histological damage with atrophy of cells and pyknosis of nuclei in guinea pigs 3 and 4 (Figs. 1 and 2). Neither iron staining nor histological injury was detected in the pituitaries of animals receiving saccharated iron oxide or 'ferric chloride caramelate'.

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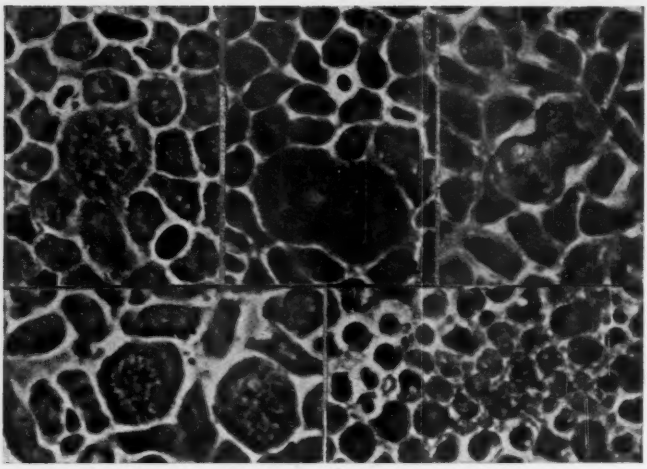
Effect on Lymphocytes of Ionizing Radiation

The increasing use of radioactive material makes the biological assay of the effects of ionizing radiation of importance. Lymphocytes are agreed to be the most sensitive mammalian cells available for the study of such effects; Trowell[1] has recently published his findings using whole animals and organs. Elsewhere, one of us[2] has described a method whereby human cells can be maintained alive for periods up to fourteen days without the elaboration of traditional tissue culture technique. All that is needed is 3 per cent agar in distilled water, of which 1 c.c. is added to 2 c.c. of equal parts of human serum



All photographs are of living serum agar cultures of human lymph glands. Phase contrast. × 1,400

Figs. 1–4. Mitosis in non-irradiated cultures; the photographs are of different cells

Fig. 5. Culture 24 hr. after irradiation with 90 r.

and Tyrode's solution. Small squares of agar are cut out of poured plates, and mounted on microscope slides. If human lymph glands are scraped with a scalpel, the resultant juice may be planted on this agar; a cover-slip is applied and the preparation is sealed with paraffin wax. The lymphocytes move actively at 37° C., and several types of cells may be recognized; some of these proceed readily to mitosis.

A small radium applicator mounted in lead has been used so that 350 r. of gamma radiation could be administered per hour to the culture. Within one hour of the application of 350 r., marked nuclear changes occur in the small lymphocytes; larger cells, probably from the reticulo-endothelial system, are not affected. The lymphocytes become progressively less motile, and most of them necrose within twenty-four hours after a series of nuclear changes. Controls survive and move actively for at least five days.

Normal lymph glands are readily obtained from the omentum in cases of gastrectomy for peptic ulcer.

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Effect of Acetoacetate on the Succinic Acid Oxidase System

The effect of alloxan, a well-known diabetogenic substance, on blood glutathione[1] and enzymes[2] indicates that it is possible that its diabetogenic action may be through its effect on enzyme systems. Lazarow[3] has discussed this possibility at length, and has also suggested that acetoacetic acid or a related compound may have a direct toxic action on the enzymes in the beta-cells of the pancreas and may thereby have an alloxan-like action. The recent findings reported from this laboratory[4] that blood glutathione is lowered by acetoacetate injection may serve as an additional indication of acetoacetate acting adversely on sulphydryl enzymes. In a preliminary observation on a simple —SH enzyme papain[5], it was noticed that acetoacetate could completely inactivate the enzyme at a concentration of 16 m*M*.

We have now investigated the effect of acetoacetate on the succinic oxidase system. This system was chosen for investigation because: (i) it is the simplest —SH enzyme known to be present in almost all tissues, including the beta-cells of the pancreas; and (ii) it is an important member of Krebs's tricarboxylic acid cycle.

Succinic oxidase activity was estimated in a Warburg apparatus by the method of Schneider and Potter[6], using rat liver homogenate as the source of the enzyme, the substrate being at a concentration of 0·05 *M*. When both the enzyme and acetoacetate were added simultaneously to other reactants, it was observed that acetoacetate effectively inhibits the enzyme only in concentrations comparable to that of the substrate. Thus acetoacetate in a concentration of 0·04 *M* was found to inhibit the activity to the extent of 79·2 per cent. Only 18 per cent inhibition was noted in presence of 0·0024 *M* acetoacetate. The effect of intermediate concentrations of acetoacetate showed that its action is progressive, the inhibitory effect depending on the time of incubation as well as on the concentration of the inhibitor.

When the tissue homogenate is subjected to preliminary incubation in the side-arm with acetoacetate prior to its addition to other reactants in the main compartments of the Warburg flask, extremely small amounts of the inhibitor are found to be effective. Thus 2×10^{-4} *M* concentration of acetoacetate completely inhibited the enzyme activity. The least concentration of acetoacetate to obtain observable inhibition (8 per cent) is $0{\cdot}4 \times 10^{-4}$ *M*.

Protection of the enzyme with glutathione. It was found that glutathione protected the enzyme only when it was present prior to the addition of acetoacetate to the enzyme. When added after the action of the inhibitor on the enzyme was complete, it usually failed to reverse the inhibition. Protection to the extent of only 80 per cent activity was afforded by $2{\cdot}6 \times 10^{-3}$ *M* glutathione. It will thus be clear that the enzyme cannot be completely protected even when the concentration of glutathione is more than several times the molecular equivalent of acetoacetate; $3{\cdot}2 \times 10^{-4}$ *M* glutathione gives 12 per cent protection to the activity of the enzyme. All experiments on protection with glutathione were conducted in presence of that concentration of acetoacetate which completely inhibits the enzyme.

Probably the carbonyl function of the acetoacetate molecule reacts with the active sulphydryl group of the enzyme, thus making it impossible for the substrate succinate to form the enzyme-substrate complex.

The results presented here indicate that an accumulation of over-production of acetoacetate may upset the normal carbohydrate metabolism. It may interfere either directly, inhibiting the —SH enzymes, or by affecting the glutathione content of the cells. Glutathione, the naturally occurring tripeptide, serves to protect the —SH enzymes of the cells and thus maintains them in an active state. Several enzymes in the beta-cells of the pancreas may also require active sulphydryl groups[2]. If these are involved in insulin synthesis, then acetoacetate at high concentration may inhibit the production of insulin also. Certain observations by Nath and Brahmachari[7] indicate that some such disturbances can be induced by acetoacetate in the production of insulin in the living system.

A detailed report regarding these investigations will be published elsewhere. We are grateful to the Indian Council of Medical Research for the award of a research grant to one of us (V. G. H.).

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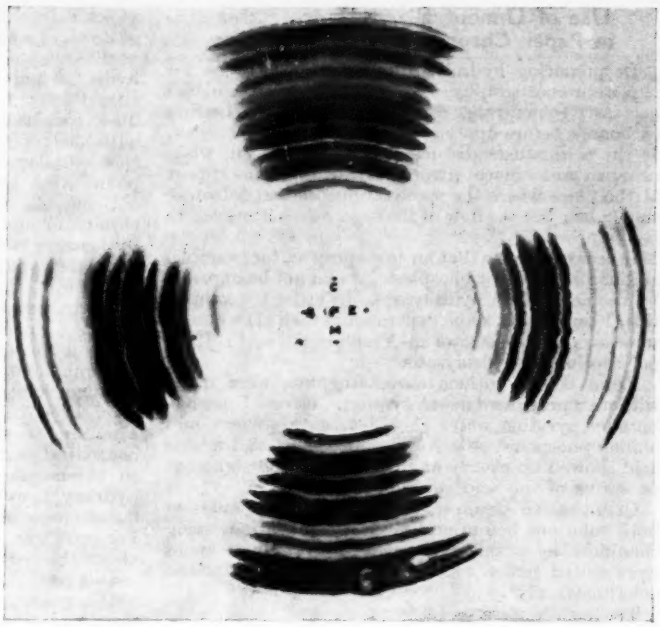
Filter-Paper Disk Chromatography

In a recent communication by Proom and Woiwod[1] commenting on circular paper chromatography, they state: "although the method is admirable for the separation of two or three substances, it is not a satisfactory substitute for large-scale paper chromatography in the separation of more complex mixtures such as protein hydrolysates".

A brief description of this technique was communicated on October 4, 1951, and first published in the November 1951 issue of *Current Science*[2]. A modification of this technique for the separation and identification of amino-acids was communicated to *Nature* on November 19, 1951, and published in *Nature* of May 31, 1952[3]. The paper by Proom and Woiwod[4] was published in the October 1951 issue of the *Journal of General Microbiology* and was received in India early in 1952. We could not, therefore, notice this paper before we communicated ours for publication. It is obvious that our technique was developed independently of Proom and Woiwod's report.

Our experience with this technique for the past one and a half years and the results so far obtained by the application of this technique to the separation of amino-acids in protein hydrolysates show without any doubt that it is well suited to the separation, identification and even quantitative estimation of most of the amino-acids present in protein hydrolysates, as is evident from the papers published by us[5]. The failure to achieve separation of a large number of amino-acids present in protein hydrolysates by this technique as reported by Proom and Woiwod is probably due to the use of solvents such as *m*-cresol and small-size filter papers (12·5 cm. diameter) in the investigations reported in their paper. We have been able to separate all the amino-acids present in protein hydrolysates by using *n*-butanol – acetic acid – water (40 : 10 : 50), pyridine – water (80 : 20); and pyridine – amyl acetate – water as solvent mixtures. The use of large-size (35 cm. diameter) filter papers is found to be more advantageous for better resolution. The accompanying photograph is of a typical chromatogram showing the separation of amino-acids present in casein, gelatin and edestin hydrolysates into as many as eleven distinct bands on a large sheet of filter paper (22½ in. × 18¼ in.).



Chromatogram showing the separation of amino-acids present in the hydrolysates of casein (*C*), gelatin (*G*) and edestin (*E*). *M*, mixture of known amino-acids. Whatman No. 1 filter paper (18¼ in. × 22½ in.), *n*-butanol – acetic acid – water (40 : 10 : 50), solvent used. 20 µl. of hydrolysate (12·5 per cent nitrogen) spotted

The wide application of this technique to the investigation of many problems in this laboratory indicates its value in chromatographic analysis.

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Use of Unneutralized Hydrolysates in Paper Chromatography of Sugars

In preparing hydrolysates of polysaccharides for paper chromatography, it has always been considered necessary to neutralize the sulphuric acid with barium carbonate before applying the solution to the paper, as the acid causes disturbing stains. Indeed, when using an ammoniacal silver spray, white stains appear at the place where the spots of glucose and galactose should be; but the flow of the sugars does not seem to be disturbed.

It occurred to me that an acid spray as, for example, aniline phthalate or phosphate, would not be impeded by the acid of the hydrolysate. In order to examine this, I carried out some experiments with (1) a simple solution of some sugars in *N* sulphuric acid; (2) a polysaccharide hydrolysate.

From both solutions chromatograms were made without previous neutralization, using benzene–butanol–pyridine–water (1–5–3–3) as a solvent and aniline phosphate as a spray. All sugars and uronic acid showed up clearly at their usual places, whereas no stains of the acid could be detected.

Quantitative determinations were also made on both solutions before and after neutralization, using rhamnose as a reference sugar. The sugar zones were eluted under reflux and the sugars estimated colorimetrically[1].

The results were as follows:

Solution of Sugars in *N* Sulphuric Acid

	mgm. added	mgm. found: in acid solution	mgm. found: in neutral solution
Galactose	10	10·6	10·4
Glucose	10	9·6	9·4
Arabinose	20	20·2	19·8
Xylose	40	39·8	39·0

Polysaccharide Hydrolysate

	Acid hydrolysate	Neutralized hydrolysate
Galacturonic acid	2·6 per cent	2·8 per cent
Galactose	1·2 „	1·5 „
Glucose	3·8 „	3·6 „
Arabinose	8·7 „	8·6 „
Xylose	67·1 „	65·6 „

The results obtained show clearly that it is not necessary to neutralize the hydrolysates of polysaccharides before applying them to paper chromatograms, provided an aniline phosphate or phthalate spray is used.

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Detection of some Precursors of Adrenaline by Paper Chromatography

During studies on the biosynthesis of adrenaline, both *para*- and *meta*-hydroxyphenylethanolamine have been found to form noradrenaline following ultra-violet irradiation in the presence of air[1]. Whereas the *para* compound has been identified in *Octopus vulgaris*[2], the *meta* compound has not hitherto been found occurring naturally. Their detection in biological materials is a major problem. With the aid of paper chromatography, using a solvent of butanol (4 vol.), glacial acetic acid (1 vol.) and water (5 vol.), we have found that the *meta* compound exhibits an intense violet fluorescence under ultra-violet light when the developing agent is a mixture of 9 vol. of a solution of either potassium ferricyanide or dichromate (0·66 per cent) and 1 vol. of formaldehyde (40 per cent), followed by exposure to heat (100° C.) for 5 min. As little as 0·5 μgm. (R_F value 0·56) can be identified by this test. Development with the *p*-nitraniline reagent[3] results in a dark red spot (similar to that produced with the *para* compound), but this test is only sensitive to 5 μgm.

Using the mixture of ferricyanide (but not dichromate) and formaldehyde as developer, followed by heating at 100° C., we have now found that noradrenaline (R_F value 0·28) exhibits a turquoise fluorescence in ultra-violet light, and as little as 0·2 μgm. can easily be detected on chromatography paper. Under similar conditions, adrenaline (R_F value 0·36) shows a yellow-green fluorescence if a minimum of 0·4 μgm. is present. Adrenaline in simple alkaline solution develops a transient green fluorescence, and Gaddum and Schild[4] in 1934 directed attention to the specificity of this reaction at low concentrations. Many substances chemically related to adrenaline (for example, noradrenaline and dihydroxyphenylalanine) produce the same green fluorescence only in much stronger concentrations. For example, West[5] found that noradrenaline is about thirty-three times less active than adrenaline in this test.

Using chromatography and the new developer (ferricyanide and formaldehyde mixture), noradrenaline is twice as active as adrenaline, so that very small amounts of noradrenaline can be detected in the presence of much larger quantities of adrenaline. Under similar conditions, both hydroxytyramine (R_F value 0·39) and dihydroxyphenylalanine (R_F value 0·19) show a yellow fluorescence if a minimum of 1·0 μgm. is present.

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Occurrence of Hydroxylamine in Lake Waters as an Intermediate in Bacterial Reduction of Nitrate

The occurrence of hydroxylamine as an intermediate of the enzymatic reduction $NO_3^- \rightarrow NH_3$ or oxidation $NH_3 \rightarrow NO_3^-$ has recently interested many biochemists[1]. Thus certain authors have been able to confirm the formation of this compound in the process of the oxidation or reduction of nitrogen compounds[2,3].

The following observations (see table) show that hydroxylamine occurs in the water of Kizaki-ko, a mountain lake in Central Japan, mesotrophic in nature and with a maximum depth of 29·5 m. In this lake, in the middle of autumn, there appears every year a very pronounced stratification of inorganic nitrogen compounds. At the beginning of summer, the nitrate increases with increasing depth, and as the period of stagnation proceeds, the oxygen content decreases in the bottom layers. In these layers, the activities of nitrate-reducing bacteria

VERTICAL DISTRIBUTION OF OXYGEN AND INORGANIC NITROGEN COMPOUNDS IN LAKE KIZAKI-KO

(1) June 3, 1952. Bottom reached: 29 m.

Depth (m.)	Water temperature (° C.)	Dissolved oxygen (c.c./l.)	Nitrate nitrogen (mgm./l.)	Nitrite nitrogen (mgm./l.)	Hydroxylamine nitrogen (mgm./l.)	Ammonia nitrogen (mgm./l.)
0	16·25	6·69	<0·02	<0·001	<0·001	0·018
2·5	15·78	7·07	"	"	"	0·012
5	15·68	6·83	"	"	"	0·016
7·5	13·71	6·83	"	"	"	0·030
10	9·93	7·04	"	"	"	0·016
12·5	8·83	6·84	"	"	"	<0·01
15	8·08	6·02	"	0·0075	tr.	"
17·5	7·36	6·02	0·04	<0·001	<0·001	0·012
20	6·81	6·03	0·04	"	"	<0·01
22·5	6·60	5·99	0·06	"	"	0·018
25	6·42	5·88	0·05	"	"	0·018
27·5	6·40	5·22	0·05	"	"	0·018
Above the bottom* (cm.)						
20		4·63	0·06	<0·001	<0·001	0·018
10		4·63	0·06	"	"	0·022
5		4·79	0·07	"	"	0·030
0		5·07	0·04	"	"	0·030
(2) September 5, 1952. Bottom reached: 28·5 m.						
0	24·8	5·77	<0·02	<0·001	<0·001	<0·01
2·5	24·71	5·67	"	"	"	0·018
5	24·60	5·45	"	"	"	0·018
7·5	18·90	5·71	"	"	"	0·018
10	13·82	4·86	"	"	"	0·016
12·5	10·76	4·33	0·08	"	"	0·016
15	9·74	4·30	0·07	"	"	0·018
17·5		4·08	0·15	"	"	0·018
20		1·98	0·20	"	"	0·016
22·5		1·73	0·16	"	"	0·018
25		0·56	0·28	"	"	0·018
26			0·28	0·004	0·004	0·018
27·5			0·19	0·012	0·007	0·016
28			0·11	0·014	0·011	0·016
Above the bottom* (cm.)						
40		0·42	0·09	0·016	0·011	0·020
20		0·31	0·08	0·019	0·011	0·020
5		0·49	0·06	0·019	0·011	0·020
0	6·60	0·39	0·05	0·015	0·021	0·023

* These samples were collected by a special sampler devised in our laboratory.

become vigorous, and stratification of nitrogen compounds results. A regular decrease in nitrate from the layer at 26 m. down to the bottom corresponds to a regular increase in nitrite and hydroxylamine. Thus it seems that these two compounds are produced by the bacterial reduction of nitrate, favoured by an environment poor in oxygen.

Determination of hydroxylamine was carried out using the modification proposed by R. Novak and P. W. Wilson[2]. Details of the present investigation will be published elsewhere.

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Asexual Reproduction in *Pygospio elegans* Claparède (*Polychæta sedentaria*)

DURING the course of an ecological investigation of the polychæte annelid *Pygospio elegans* Clap., a remarkable mode of asexual reproduction was noticed. The species were collected at the small island of Vorsø in the Horsensfjord (East Jutland, Denmark) and the phenomenon was first observed in April 1949.

Pygospio lives in quite shallow water, where its thin tubes are found vertically in the sandy bottom. Normally, it has sexual reproduction with pelagic or non-pelagic larvæ according to different quantities of nurse eggs[1]. It has now been found able to reproduce asexually. The bodies of the adults, both males and females, divide into pieces consisting of varying numbers of segments, generally about three or four, sometimes up to seven; several times fragments consisting of one segment only have been observed. Fission takes place in any part of the body. When just separated, the single fragment looks as if it had been cut off with a knife. After the division, the series of fragments will stay in the tube until each has developed into a new animal. The fragments are very active and move up and down in the tube, which they never leave, however, until regeneration is completed. Every single fragment is able to form a new individual exclusively from its own tissue. The rate of regeneration is very high, and at 20° C. the regeneration of a new animal was completed in eight days; then the asexually formed individual will start a new division process. The original fragment is so closely incorporated into the new animal that no difference between old and new segments can be seen. So far as I know, this is the first case of asexual reproduction described in a species of the family Spionidæ.

At Vorsø, asexual development can be found at any time of the year; as a rule only a few adult individuals are seen dividing. In the early spring, however, just after normal sexual reproduction has ceased (at Vorsø sexual breeding occurs in winter), asexual reproduction rises to a maximum.

In 1949, the asexual period was rather short (from the end of April to the beginning of May) and nearly all adult animals examined were dividing.

In 1950 the period was much longer (from the middle of March to the end of April), and only a minor part of the adult population was dividing.

Preliminary experimental work has shown that temperature significantly influences the asexual reproduction. Outside the natural period of asexual reproduction, it is possible to induce fission and regeneration by exposing adults to temperatures of 4–5° C. Weather observations from the spring periods of 1949 and 1950 seem to confirm the importance of temperature. In 1949 the break of the frost occurred very suddenly and in a short time the average temperature of the day period increased to about 10° C., while in 1950, the rise of temperature occurred very slowly; this may explain the differences in the asexual breeding in 1949 and 1950.

The mode of reproduction described above, when occurring generally, may have interesting ecological effects. Thus if the organism is decimated by a severe winter, asexual breeding will make possible a rapid recovery of numbers.

Further investigations of *Pygospio elegans* have been made at other Danish localities, especially the Isefjord (Zealand), and at various seasons; but so far asexual reproduction has only been observed at Vorsø in the Horsensfjord.

The accompanying drawing shows two segments of a mature male *Pygospio* with regenerated head and tail part, the head being the younger section. The investigations are being continued, and later on a more detailed report will be published elsewhere.

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A Gene for Photoperiod Sensitivity in Rice linked with Apiculus Colour

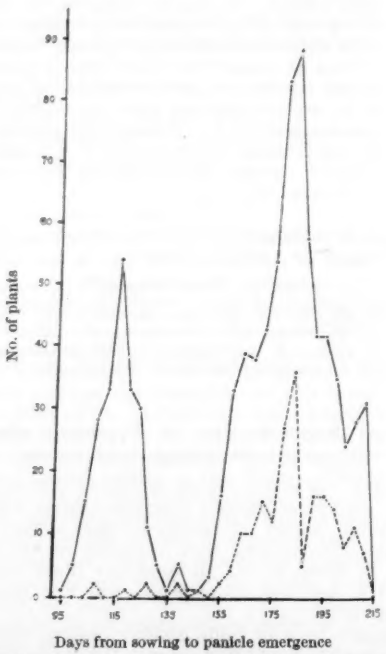
Lack of appreciation of the importance of length of day in determining the onset of flowering has vitiated much of the earlier work on the inheritance of age in rice. No genetic analysis of photoperiod response in this plant has yet been published. In the past two years, I have investigated the inheritance of photoperiod sensitivity. The Ceylon pure line, Vellai Ilankalayan 28061, which blooms approximately one hundred days after sowing, and is relatively insensitive to the photoperiod, was crossed with the Burma lines, *MLYC* 401 and *HMC* 12, which have, in the short days of the North-East Monsoon season, about the same sowing-to-flowering interval as the former, but are, to a high degree, sensitive to the photoperiod. The annual variation in length of day in Ceylon (lat. 5° 55′–9° 50′ N.) is less than one hour, but this variation exerts a profound influence on the flowering of the sensitive varieties. The growing of segregating progenies in the long days of the South-West Monsoon season makes the separation of sensitive and day-neutral forms possible. The parents and the F_1 and F_2 generations were sown at the same time, namely, May 1, 1952, at the Rice Research Station, Batalagoda. The mean intervals from sowing to panicle emergence for the parents and the F_1 are shown in Table 1.

Table 1

Generation	Mean No. of days from sowing to panicle emergence
Parents { Vellai Ilankalayan 28061	105 ± 2·65
Parents { *MLYC* 401	164 ± 2·29
F_1	169 ± 1·87

Sensitivity shows complete dominance in the F_1 generation. The apparent heterosis is not significant. The segregation of the F_2 is illustrated in the accompanying graph, and is seen to be bimodal. The first mode corresponds to the emergence of the day-neutral segregates, and the second to the sensitive segregates. The numbers in the two classes fit well, as is shown in Table 2, into a monohybrid ratio, and indicate the determination of sensitivity by a single pair of genes to which I propose assigning the symbols, *Se se*.

The analysis of the F_2 segregation revealed the linkage of sensitivity with apiculus colour, *Ap ap*. The genes enter the cross in the repulsion phase, *Se ap/se Ap*; Vellai Ilankalayan 28061 is homozygous for the dominant purple apiculus, and *MLYC* 401 for the recessive white apiculus. The distribution of



Segregation in F_2 for sensitivity and apiculus colour. ——, total plants; – – – –, plants with white apiculus

Table 2

	No. of plants in F_2 segregation		
	Sensitive	Day-neutral	Total
Observed	666	216	882
Expected on 3 : 1 ratio	661·5	220·5	882

$\chi^2 = 0{\cdot}122$; $P = 0{\cdot}95 - 0{\cdot}50$.

plants with a white apiculus is illustrated in the graph. The observed numbers of plants in the F_2 classes and the expectations based on independence are given in Table 3.

Table 3

	No. of plants in F_2 segregation				
	Sensitive, apiculus purple	Sensitive, apiculus white	Day-neutral, apiculus purple	Day-neutral, apiculus white	Total
Observed	470	196	211	5	882
Expected on 9:3:3:1 ratio	496·1	165·4	165·4	55·1	882

$\chi^2 = 197{\cdot}276$; $P < 0{\cdot}01$.

The cross-over value for the two pairs of genes estimated from the F_2 is $16{\cdot}3 \pm 3{\cdot}26$ per cent.

Photoperiod sensitivity showed similar F_2 segregation and linkage with apiculus colour in crosses with *HMC* 12.

A full account of this work will be published elsewhere.

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Contamination of *Azotobacter chroococcum* by Gram-negative Bacterial Rods

In a recent investigation, it proved virtually impossible to obtain a pure culture of *Azotobacter chroococcum*. After initial isolation from soil in flasks containing 2 per cent mannitol and 0·02 per cent sodium phosphate in tap water, progressive subcultures were made on solid nitrogen-free medium containing washed agar and the same percentages of mannitol and phosphate in distilled water—a recognized procedure for purifying *Azotobacter*[1]. Characteristic colonies of *Azotobacter* were obtained in about a month, and stained smear preparations of these colonies revealed only the characteristic large cells of the organism. If, however, colonies were inoculated into peptone water (in which *Azotobacter* will not grow[2]) a faint haze due to growth of small Gram-negative rods appeared after 24–48 hr. incubation at 22° C. A more abundant growth of these rods was obtained in 24 hr. on nutrient agar containing 0·1 per cent whole milk, whereas on this medium the growth of *Azotobacter* was very poor after three to four days. Subculture of *Azotobacter* on solid nitrogen-free medium (above) was therefore extended up to periods of four months, and 0·1 per cent sodium silicate, 0·002 per cent iron ($FeCl_3$) and boron, 0·00004 per cent sodium molybdate, soil extract and hay-infusion were incorporated in some cultures to heighten the resistance of *Azotobacter*. In practically all cases, however, the contamination persisted. On the one or two occasions on which it appeared to be absent, growth of *Azotobacter* was very poor, marked by absence of the characteristic mucilage, and ceased within seven to fourteen days; nor could it be restored by incorporation of any of the above substances. Fourteen strains of contaminants were isolated the cultural characters of which proved conclusively they were not pleomorphic forms of *Azotobacter*, the majority being strains of *Pseudomonas* (fluorescent and non-fluorescent) with one or two species of *Achromobacter*. In the absence of *Azotobacter*, they grow well up to four weeks in flasks of the above liquid mannitol medium, reducing its reaction to a *p*H of 4·0 in a fortnight although growth was still vigorous. Their source of nitrogen in such cultures is obscure. They grew in liquid media, distilled water with 1 per cent glucose and ammonia (0·1 per cent $(NH_4)_2HPO_4$) as the sole source of nitrogen; but only feebly in 1 per cent glucose only. Incorporation of whole killed cultures, extracts or filtrates of cultures improved growth of *Azotobacter* on solid nitrogen-free media and improved its mucilage production.

Large numbers of contaminants depressed the growth of *Azotobacter* in nitrogen-free liquid media when they were grown in association. Fluorescent strains of *Pseudomonas* destroyed the *Azotobacter* cells.

All the contaminants were freely ingested by soil ciliate protozoa which multiplied in their presence. Fluorescent *Pseudomonas* inhibited growth of *Colpoda* sp. but not, for example, *Urostyla grandis*, which fed upon it.

Azotobacter is reported to be accompanied in Nature by a small Gram-negative rod *Radiobacter*[3] the relationships of which are ill-defined. The present findings suggest that association with common Gram-negative rods may persist unsuspected in laboratory cultures regarded as pure.

These observations were carried out when I was serving as senior bacteriologist in the National Agricultural Advisory Service of the Ministry of Agriculture, and thanks are due to C. D. Oxley, provincial bacteriologist, and F. W. Catton, assistant bacteriologist, for material advice and assistance.

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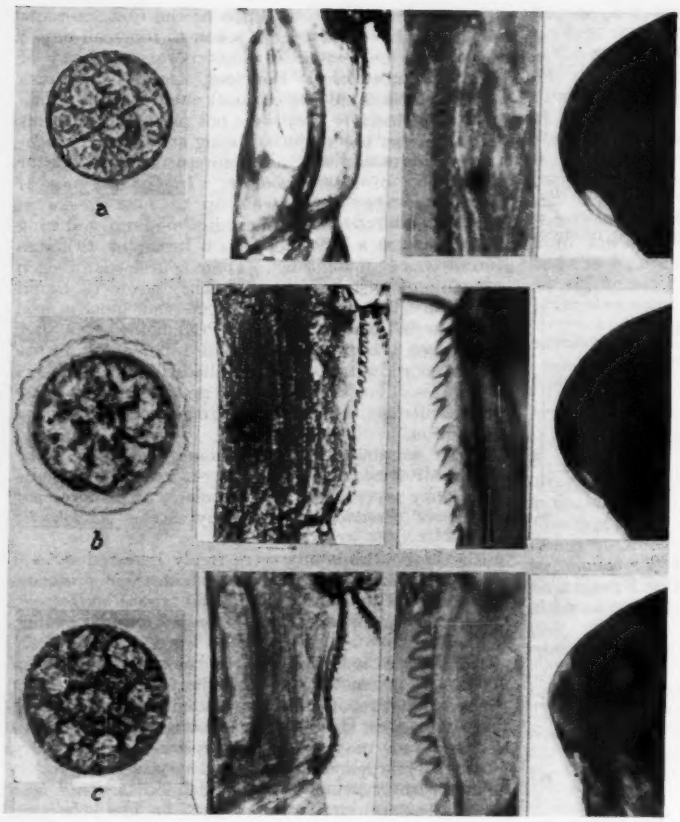
Calanus finmarchicus and Related Forms

The copepod *Calanus finmarchicus* has been more thoroughly investigated than any other marine plankton organism. Some systematists have recognized in the material from European[1] and eastern American waters[2] two distinct species, *C. finmarchicus* and *C. helgolandicus*; but the distinguishing characters given have been too uncertain to receive universal acceptance[3]. In consequence, it has been assumed in most studies of the copepod—its population changes, physiology, behaviour, etc.—that the material used consists of a single species. Recently[4], it was pointed out that two forms, corresponding to the two species, could be readily distinguished in the female and copepodite stage V by the structure of the basipod of the fifth swimming feet, though their status, whether species or sub-species, remained



Typical eggs, the basipod segment of the left fifth legs, the proximal teeth of the basipod of the right fifth legs and the foreheads of females of (*a*) *Calanus finmarchicus*, (*b*) the *Calanus* from Tromsø, and (*c*) *C. helgolandicus*

undecided. It has also been shown[5] that the eggs of *helgolandicus* are bigger (165–180 μ in diameter) than those of *finmarchicus* (135–155 μ). Following upon the more definite means of identification, it is becoming recognized that in future research the two forms should be distinguished[6].

In the early spring of 1952, in Tromsø Sound, northern Norway, the majority of female *Calanus* caught were *finmarchicus*; no *helgolandicus* was found. About 10 per cent, however, laid eggs of the same size as *helgolandicus*; but these, shortly after laying and before the first cleavage, produced a rugose membrane with a clear space between it and the egg, varying in width (see photographs). These eggs were viable and hatched into nauplii slightly larger than those of the normal *finmarchicus*.

Out of well over a thousand females observed laying eggs in the laboratory at Millport, two have produced similar eggs with membranes; but in neither case were the eggs healthy and unfortunately neither of the females was examined in detail.

Some of the Tromsø females which laid these eggs were later examined and compared with typical examples of *finmarchicus* and *helgolandicus* (see photographs). In *finmarchicus* the teeth of the basipod of the fifth legs are arranged along the edge of the segment and are numerous and small; the forehead is evenly round. In *helgolandicus* the tooth line curves round to the posterior side of the segment, giving a marked concave appearance to the inner margin of the segment, the teeth being fewer and larger than in *finmarchicus*; the forehead is more or less pointed. The *Calanus* from Tromsø show mixed and intermediate features of the two forms so far recognized. The tooth line is curved, but the curvature is small and more like *finmarchicus* than *helgolandicus* in this respect; but the teeth are similar to those of the latter in number and size; the forehead resembles *finmarchicus* in being evenly round.

Morphologically, the Tromsø *Calanus* are sufficiently distinctive to constitute a third form. Two possible interpretations immediately present themselves. The first, and the more likely, is that they have the same status as *C. finmarchicus* and *C. helgolandicus*, be this species or sub-species. The second is that they have arisen through interbreeding of the two other forms. This seems less likely, for in the areas where these two forms are commonly found together, the Tromsø form is extremely rare or absent, whereas it formed up to 10 per cent of the catch in the Arctic where *C. finmarchicus* predominates.

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Life-history of *Fasciola gigantica* Cobbold 1856

Following the elucidation by Thomas[1] of the life-history of *Fasciola hepatica*, numerous investigations have established the important aspects of the relationship between the fluke and its snail hosts. By contrast, knowledge of the related *F. gigantica* is extremely limited, and in many parts of the world even the identity of its vectors has not been confirmed.

During the course of a recent field survey which was initiated by the Food and Agriculture Organization of the United Nations as part of a programme of liver-fluke control in Pakistan, the Veterinary Laboratory of the Ministry of Agriculture at Weybridge was used as a central laboratory for experimental work for which facilities did not exist in Pakistan. At Weybridge, the use of laboratory techniques

which had been developed for work on *F. hepatica* and its host *Lymnæa truncatula* made it possible readily to observe the development of *F. gigantica* under controlled conditions both in molluscs and in mammalian hosts.

Snails which had been collected near Rawalpindi in Pakistan were kept under observation in shallow earthenware dishes of water at the Central Laboratory of the Animal Husbandry Department, Peshawar. Egg-laying commenced within three weeks. On February 2, 1952, two egg masses were sent by air to England. Snails from these egg-masses were exposed to infection with the miracidia of *Fasciola gigantica* (also of Pakistan origin) on March 24. Development of the parasite proceeded to completion at laboratory temperatures, emergence of mature cercariæ being first observed on June 10, 78 days after infection.

Starting on July 3, a lamb (aged fifteen weeks) was given a total of two hundred cercariæ over a period of nine days. On October 21 (110 days later), eggs of *Fasciola gigantica* were recovered from the fæces. An identical period of time proved necessary for the full development of the parasite in a calf. This may be compared with an average of about seventy days necessary for the development of *Fasciola hepatica* both in sheep and in calves.

The snails used in these observations have been identified for us by Mr. G. L. Wilkins, of the British Museum (Natural History), as *Lymnæa rufescens* Gray (a species considered by Hubendick[2] to be merely a race of the well-known *L. auricularia*). *L. auricularia rufescens* (Hubendick[2]), showing great variation in shell morphology, occurs widely throughout east and west Pakistan, where field observation suggests that it is the principal vector of *Fasciola gigantica*. Most shells are similar to the forms of *L. acuminata* described by Annandale and Rao[3]. The snails are often found as true aquatics in large bodies of permanent water, the frequent connexion with deep pools possibly having an association with a negatively phototropic reaction which we have observed in the miracidia of *F. gigantica*. This response, although not noted by Alicata[4] in Hawaii, is, under our laboratory conditions, most marked and in direct contrast to the strong positive phototropism of the miracidia of *Fasciola hepatica* which in Pakistan, as in Europe, parasitizes the amphibious *L. truncatula*.

At Weybridge *L. auricularia rufescens* has readily accommodated itself to a restricted habitat. Management very similar to that recommended by Taylor and Mozley[5] for the culture of *L. truncatula* has proved satisfactory, although it has been found necessary to maintain a depth of one to two inches of water in the culture dishes.

Further observations on the life-history are being made and will be recorded at a later date. In particular, we are interested in the possibility of the British *L. auricularia* (L.) proving susceptible to infection with *Fasciola gigantica*.

S. Brian Kendall
J. W. Parfitt

Ministry of Agriculture Veterinary Laboratory,
New Haw, Weybridge,
Surrey.
Jan. 14.

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A Method for the Bulk Growth of a Parasitic Protozoan

The biochemical study of protozoan species has been hampered by the difficulty of obtaining large quantities of clean, dried organisms to serve as starting material for investigation. The solution of the problem of bulk growth of the protozoan cattle parasite, *Trichomonas fœtus*[1], made possible an immunochemical study of the organism[2].

Trichomonas vaginalis, a protozoan parasite of man, presents a similar problem. Strains isolated in a bacteria-free state by the use of antibiotics[3] can be grown in culture media in current use, but in the best reported conditions only about 2×10^6 organisms per ml. are obtained after three to four days in 5 or 10 ml. quantities of medium. For the practical harvesting of dried organisms, litre quantities of culture containing $4–5 \times 10^6$ organisms per ml. are desirable[3]. A further drawback of most published media for *T. vaginalis* is the inclusion of particulate matter (agar or rice starch), which makes it difficult or impossible to collect the organisms in the pure state.

The starting point for the current investigation was the agar-free modification by McEntegart[4] of the C.P.L.M. medium of Johnson and Trussell[5]. It was determined that a Liverpool strain of *T. vaginalis*, which had become adapted to McEntegart's medium, would grow in it at $1–1·5 \times 10^6$ per ml. when sub-cultured at 48-hr. intervals. Stepwise modification of this medium led to the following formula for a medium in which this Liverpool strain will attain a growth-level of $4–6 \times 10^6$ per ml. within 24 hr. and which will support such growth in bulk volumes.

Ascorbic acid	3·7 gm.
L-Cysteine hydrochloride	2·5 gm.
Proteolysed liver B.P.C. (ref. 6)	1·0 gm.
Glucose	10·0 gm.
Distilled water	1,200·0 ml.
Bovine serum	160·0 ml.
Douglas's digest broth, double strength (ref. 7)	1,000·0 ml.
M Sodium hydroxide to *p*H 5·8–6·0	

The medium is sterilized by passing through a Seitz filter and should be used within fourteen days. For tube-growth, 10-ml. amounts are inoculated with 0·5 ml. of an actively growing culture and incubated at 36–37° C. Sub-culturing is done daily.

Bulk growth is carried out in 80-oz., narrow-necked, round bottles, using 2 litres of medium per bottle. The necessary inoculum for each bottle is obtained by successive 24-hr. subcultures in (*a*) a tube and (*b*) 100 ml. of medium in an 8-oz. flat medicine bottle. The medicine bottle receives 5 ml. inoculum from the tube and contributes 100 ml. inoculum to the bulk bottle. All bottles are warmed in the incubator for 24 hr. prior to inoculation.

The organisms from the bulk cultures are collected and thrice washed by centrifugation and re-suspension in saline. After the final centrifugation they are suspended in a small quantity of distilled water, frozen and dried from the frozen state. The yield is 1·1–1·5 gm. dried organisms per bottle.

The suitability of this culture medium for *T. vaginalis* has been further demonstrated by the successful isolation of two new bacteria-free strains from clinical material, using 1,000 units penicillin and 500 units streptomycin per ml. Initial growth was slow; but after several passages the strains (Whitechapel 1 and 2) adapted themselves to the

medium and are now growing at 4–5 × 10^6 per ml. A single attempt at bulk growth with Whitechapel 1 yielded 1·17 gm. from one bottle.

Of special interest is the observation that proteolysed liver B.P.C.[6] can replace the 'Difco' liver infusion called for in the C.P.L.M. medium[4,5]. Attempts to grow the organisms without liver (or a substitute infusion of human red blood cells) were unsuccessful. Proteolysed liver B.P.C. is a completely soluble, inexpensive material and may prove useful as a substitute for liver infusion or as a growth-promoting inclusion in media for the culture of other micro-organisms.

A fuller account of this investigation will be reported elsewhere. I am indebted to Dr. M. G. McEntegart, Liverpool City Bacteriological Laboratory, for his original culture and medium; to Dr. Claude Nicol, Whitechapel Clinic, for clinical specimens; to Messrs. Paines and Byrne, Ltd., Greenford, Middlesex, for generous quantities of 'Pabyrn' brand proteolysed liver B.P.C.; and to Mr. C. D. Eevis, Lister Institute, for technical assistance.

Joseph G. Feinberg*

Lister Institute of Preventive Medicine,
London, S.W.1.
May 12.

* U.S. Public Health Service Research Fellow of the National Microbiological Institute.

[1] Kerr, W. R., and Robertson, M., *J. Comp. Path.*, **57**, 301 (1947).
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Excess of Molybdenum in Herbage as a Possible Contributory Factor in Equine Osteodystrophia

Defects in nutrition which predispose to osteodystrophic conditions in the horse include a dietary deficiency of phosphorus[1] or disturbance in the vitamin D – calcium – phosphorus relationship. With regard to the influence of trace minerals, Davis[2] found that the presence of small amounts of molybdenum, ranging from 2 to 25 p.p.m. in young growing herbage, was associated with defective bone metabolism in herbivora, consequent on the effects of molybdenum on the utilization of both phosphorus and copper. More recently, Arrington and Davis[3] in limited phosphorus metabolism studies with rabbits reported that molybdenum decreased phosphorus absorption while at the same time increasing the excretion of phosphorus.

On some twelve farms where we have investigated the occurrence of clinical rachitis in one or more of the foals or yearlings, we have found that the molybdenum content of the grazing herbage has been within the range 5–25 p.p.m. The soils on these farms are mainly derived from limestone, being of a similar nature where soil type, manurial treatment and management are concerned to those on which molybdenum-conditioned copper deficiency has previously been identified by us[4]. In addition, readily available molybdenum determinations on these soils have shown values in the region where excess levels of molybdenum in herbage are likely to occur. While it has been impossible so far to ascertain to what extent molybdenum may be an etiological factor, we suggest that a foal running with its dam on such pastures would receive an excessive intake of molybdenum from the mare's milk and from the herbage. In view of the work referred to above, such a foal would be more susceptible to osteodystrophic conditions as a result of the influence of molybdenum on the metabolism of both phosphorus and copper. Consequently the extent to which molybdenum in moderate excess in pasture may predispose to the development of poor bone in the young horse and afterwards to poor performance in later life is raised.

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L. B. O'Moore

Biochemistry Section,
Veterinary Research Laboratory,
Department of Agriculture,
Ireland.
Jan. 27.

[1] Akerblom, E., *Nord. Vet. Med.*, **5**, 471 (1952).
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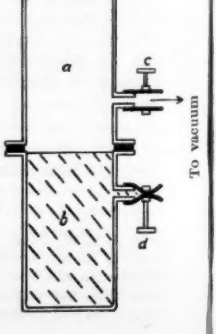
Apparatus for Infiltration of Liquids into Leaves

Vacuum infiltration of liquids into leaves is a technique that has been used for many years. So far as I am aware, the usual procedure is to keep the leaf under liquid while reducing the pressure. Air bubbles then escape from the stomata, and any adhering when the lowest pressure has been attained are dislodged, often with difficulty, by shaking the container; for when the vacuum is afterwards released the adherence of these bubbles would spoil the efficiency of infiltration. The difficulty of bubble removal is greatly increased when a number of leaves are simultaneously infiltrated, so that it is desirable to use as few leaves as possible, or even to treat them singly. To overcome such difficulties it is best to reduce the pressure while the leaves are in air, releasing pressure only after putting the leaves under liquid. A convenient way of doing this is described below.

Two glass or metal containers of suitable strength, each with a side-arm and flange, are stood one upon the other, separated by a wet rubber washer. The leaves are held in chamber *a*, and the infiltrating fluid in *b*; *c* and *d* are clips on rubber pressure-tubing (glass stopcocks could be used) attached to the side-arms of the chambers. To evacuate the apparatus, *c* is opened, and when the desired degree of evacuation, read on a gauge, is reached, closed again. The whole arrangement is now inverted so that the infiltrating liquid runs on to the leaves. Then *d* is opened so



as to release the vacuum gently, and infiltration takes place.

Generally eight to ten leaves of *Atropa belladonna*, L., each 6·5 in. long and 3–3·5 in. at the widest, were simultaneously infiltrated. They were first rolled in a springy, spiral, piece of celluloid-like material 1–1·5 in. wide, and secured if necessary with a loose rubber band. The leaves so compacted were held in chamber *a* with their petioles at the bottom, by means of a suitable spring-clip.

The method gives complete infiltration with minimal reduction of pressure, and if a good rate of evacuation is obtainable the leaves need not be kept under reduced pressure, even with the relatively large chambers used, for more than a minute.

The quantity of infiltrating liquid required depends, of course, on the volume necessary to cover the leaves. For the number of leaves and dimensions given, nearly a litre was required, of which less than 15 ml. was retained by the leaves: this extravagance of the method is sometimes a drawback.

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Feb. 4.

Inheritance of Minor Colour Vision Variations

A CONSIDERABLE amount of attention has been given to the inheritance of major colour vision defects, namely, red-green blindness and anomalous colour vision[1–6], and the view most favoured at present is that there are two groups of totally sex-linked alleles with three members in each group (together with dominant normal genes) which determine major red and green defects. Walls has recently put forward the view that there might be a third locus, also with three alleles, and totally sex-linked, which determine blue vision defects[6].

Total sex-linkage of minor blue and yellow vision defects is not supported by the fact that these variations are as frequent in women as in men[4]. A study of forty pedigrees which reveal the inheritance of blue and yellow minor colour vision defects, collected in the course of testing 649 men and 546 women, strongly suggests that some of their more extreme forms are due to the action of partially sex-linked multiple allelomorphs. Partial sex-linkage is difficult to distinguish decisively from autosomal inheritance, but seems likely.

The minor defects of blue vision are defined as: (1) blue deviation, (2) blue weakness, and (3) blue-yellow weakness with darkened violet. The distinction between 'deviation' and 'weakness' has been explained fully elsewhere[4]. It is suggested that the appropriate genes might be called: B (normal and most dominant), b_1, b_2 and b_3 (most recessive). The segregation of these genes is clearly apparent in the pedigrees, two of which suggest the dominance order and four suggest crossing-over between genes in the blue series.

The minor defects of yellow vision are defined as: (1) yellow deviation, (2) yellow weakness and (3) extreme yellow-blue weakness. The appropriate genes might be called: Y (normal and most dominant), y_1, y_2 and y_3 (most recessive). Again, segregation can be seen clearly in the pedigrees, three of which suggest the dominance order and four indicate crossing-over between genes of the yellow series.

These facts seem to favour a four-receptor theory of colour vision.

In addition, five pedigrees show totally sex-linked forms of minor red and green deviation. These are very mild forms of red and green anomaly, two pedigrees for red, two for green and one for both together. Darkening of the red is shown in one pedigree. In order to explain these, it is necessary to assume a degree of heterozygous manifestation not much less than the defects of the hemizygotes themselves, though not always the same. This may be because the appropriate genes are the most dominant, next to the normal genes in the familiar protanope and deuteranope series, and have the greatest penetrance.

In many of the pedigrees, major red and green and minor blue and yellow variations occur together and may be traced out as segregating independently. Totally sex-linked major blue defects were not found in the population tested, but may occur.

Details of this investigation will be published fully elsewhere.

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Jan. 25.

[1] Waaler, G. H. M., *Z. Ind. Abst., Vererb.*, **45** (4), 279 (1927).
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Predacious Mosquito Larvæ

APART from the obligatory cannibalism of the genus *Toxorhynchites* and the sub-genera *Mucidus* and *Lutzia*, cannibalism in other mosquito genera has been little studied. Graham[1] stated that the addition of 3 per cent common salt to the breeding water brought about cannibalism in *A. gambiæ*. This was not confirmed by subsequent work. It has, however, been observed in Mauritius that facultative cannibalism exists within the salt-water strain of *A. gambiæ*. Such a tendency has not been observed in the fresh-water strains of *A. gambiæ*.

Third- and fourth-stage larvæ can be seen to seize other larvæ, of all stages, by the abdomen and to commence to feed. This would appear to stimulate neighbouring larvæ, as within a few seconds numerous larvæ are feeding upon the hapless victim, whose vigorous struggles are usually in vain. The head capsule is all that remains, but larvæ can be seen attempting to extract the contents of the head capsule with their mouth brushes. Pupæ are immune from attack.

This tendency to cannibalism, in the presence of abundant larval food, brings about a considerable mortality in a laboratory culture. The breeding dishes are littered with head capsules each morning, the larval numbers being correspondingly reduced.

JAMES G. HALCROW

Malaria Eradication Scheme,
Floreal, Mauritius.
Jan. 17.

[1] Graham, W. M., *Bull. Ent. Res.*, **1**, 51 (1910).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, June 29

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. Warren S. McCulloch: "Some New Techniques for the Electrophysiological Study of the Central Nervous System".*

Tuesday, June 30

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Warren S. McCullock: "Through the Den of the Metaphysician".

Wednesday, July 1

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INTERNATIONAL HAEMOPHILIA SOCIETY (at 94 Southwark Bridge Road, London, S.E.1), at 6.30 p.m.—Second Meeting of the London Group.*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC OFFICER, Grade I (with university degree of high standard in physics or electrical engineering or equivalent qualification, preferably electronic) in the High Speed Aerodynamics Laboratory, Salisbury, South Australia, to be responsible to a Senior Scientific Officer for the development of instruments for aerodynamic research and the adaptation of existing instruments for special purposes—The Senior Representative (A.P.2), Department of Defence Production and Supply, Australia House, Strand, London, W.C.2 (July 3).

ASSISTANT STATISTICIANS (with first- or second-class honours degree with statistics as a main subject, or a postgraduate university diploma or higher degree in statistics) in Government Departments—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 96/53 (July 4).

BIOCHEMIST (Basic Grade) (with B.Sc. degree, preferably with honours in biochemistry or chemistry, or equivalent qualification)—The House Governor, General Hospital, Birmingham 4 (July 4).

EXPERIMENTAL OFFICER at the Ministry of Supply Experimental Flying Establishment, Salisbury, for assessment and proving of aircraft camera installations for photographic survey and reconnaissance, and development of photographic methods applied to aircraft flight-testing—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F253/53A (July 4).

LECTURER (with a first- or second-class honours degree in physics or electrical engineering or equivalent qualifications) IN THE PHYSICS AND ELECTRICAL ENGINEERING DEPARTMENT—The Director of Studies, Royal Naval College, Greenwich, London, S.E.10 (July 4).

MAY AND BAKER RESEARCH FELLOWSHIP for research work on plant growth-regulating substances—The Registrar, Wye College, Ashford, Kent (July 4).

AGRICULTURAL ECONOMIST (at Bristol), and ASSISTANT AGRICULTURAL ECONOMISTS (4, 2 at Bristol and 2 at Newton Abbot)—The Registrar, The University, Bristol 8 (July 6).

ASSISTANT EXPERIMENTAL OFFICER AT THE POULTRY RESEARCH CENTRE, EDINBURGH, to assist in investigations involving histological, physiological and biochemical techniques—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (July 6).

RESEARCH ENTOMOLOGIST (with good honours degree) for investigations on laboratory and field methods for the development and bioassay of insecticides—The Secretary, East Malling Research Station, Maidstone, Kent (July 7).

TUTORIAL STUDENTSHIP IN PHARMACOLOGY, and a TUTORIAL STUDENTSHIP IN ZOOLOGY (preferably of the vertebrates)—The Registrar, King's College, Strand, London, W.C.2 (July 7).

SENIOR RESEARCH FELLOWSHIP IN NATURAL PHILOSOPHY—The Secretary, The University, Aberdeen (July 8).

SYBIL MARY PILKINGTON FELLOWSHIP for research into diseases of the blood, with particular refer[illegible] to the causation, treatment, and cure of leukæmia in man—The [illegible]gistrar, The University, Manchester 13 (July 10).

ASSISTANT IN THE DEPARTMENT OF GEOGRAPHY—The Secretary, The University, Edinburgh (July 11).

ASSISTANT (Grade A) IN THE DEPARTMENT OF MATHEMATICS—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (July 11).

CHEMIST in a Ministry of Supply Establishment, Aldermaston, Berks, to develop and supervise a unit enaged on quantitative analysis of organic compounds by micro-combustion techniques—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.252/53A (July 11).

GRADUATE ASSISTANT IN PHYSICS (with university degree in physics, and special interest in electronics as applied to biological problems)—The Professor of Physiology, Department of Physiology, University Museum, Oxford (July 11).

STATISTICIAN (honours graduate, Scientific Officer grade)—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (July 13).

ASSISTANT LECTURER IN ECONOMIC STATISTICS in the Department of Political Economy—The Secretary, University College, Gower Street, London, W.C.1 (July 14).

ELECTRONIC ENGINEER in the Ministry of Supply, London headquarters, to supervise the development by industry of electronic navigation aids for Service use—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.223/53A (July 14).

EXTENSION LECTURER IN SCIENCE (with special qualifications in natural science, preferably biology)—The Secretary, University Extension Lectures Committee, Rewley House, Wellington Square, Oxford (July 15).

LECTURER IN EXPERIMENTAL PHYSICS—The Secretary of University Court, The University, Glasgow (July 15).

LECTURER IN MATHEMATICS at the Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

LECTURER and an ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, The University, Leeds 2 (July 15).

SENIOR EXPERIMENTAL OFFICER (with degree in a scientific or engineering subject or in mathematics, or a H.N.C., or a graduate membership of a professional institution) in the National Physical Laboratory, Teddington, to assist in co-ordinating the work of the workshops and design offices (which produce prototype precision instruments and the apparatus needed for the laboratory's research work)—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.422/53 (July 15).

SENIOR LECTURER or LECTURER (Grade I) and a LECTURER (Grade II) IN CHEMISTRY, a LECTURER (Grade II) or ASSISTANT LECTURER IN ZOOLOGY (preferably with special interests in taxonomy and ecology), and a LECTURER (Grade I) IN MATHEMATICS, at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 21).

SENIOR RESEARCH OFFICER (Chemical Engineer) (with university honours degree in science, with chemistry as major subject, or in chemical engineering, and some industrial experience, preferably in research and development) at the Wool Textile Research Laboratory, Geelong, Victoria—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 464/52 (July 25).

LECTURER IN BIOCHEMISTRY at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 31).

SENIOR LECTURER or LECTURER IN GEOLOGY at New South Wales University of Technology, Sydney, to teach geophysics and economic geology, and to undertake research in these fields—The Agent General for New South Wales, 56–57 Strand, London, W.C.2 (August 4).

CHAIR OF INORGANIC AND PHYSICAL CHEMISTRY in the University of Adelaide—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Adelaide, August 31).

SENIOR LECTURER (heavy current) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 31).

LECTURER IN BOTANY (special qualifications in Plant Physiology would be an advantage) at New England University College (University of Sydney), Armidale, N.S.W.—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Armidale, September 1).

ASSISTANT, Grade B (with good honours degree in chemistry, and able to teach organic chemistry to final degree standard) FOR CHEMISTRY—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

ASSISTANT, Grade B (with good degree in physics of a British university) IN PHYSICS—The Registrar, Medway Technical College, Gardiner Street, Gillingham, Kent.

ASSISTANT (Assistant Experimental Officer grade) for general duties IN THE PLANT PATHOLOGY SECTION—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee.

ASSISTANT METEOROLOGIST in Trinidad—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M3B/33526/NF.

ENGINEER, Grade I (Ref. 467) and ENGINEERS, Grade II and III (Ref. 468), for work on major calculations required by design offices concerned with nuclear reactors and factories for producing fissile material—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS IN THE MINISTRY OF FUEL AND POWER at Sheffield and Kidderminster, for underground gasification project exploring new technique to make gas direct from the coal seam (Ref. F256/53A); SCIENTIFIC OFFICERS FOR SAFETY IN MINES RESEARCH ESTABLISHMENTS at Sheffield and Buxton (Ref. F.257/53A); ASSISTANTS (Scientific) at Sheffield and Buxton (Ref. F.258/53A); SCIENTIFIC OFFICERS IN THE CHIEF SCIENTIST'S DIVISION, London (Ref. F.259/53A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

GEOLOGIST IN THE PUBLIC WORKS DEPARTMENT, Sudan—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, quoting "Geologist 1810".

GRADUATE IN METALLURGY, CHEMISTRY or PHYSICS, to join a group studying atomic movements in solids by means of radioactive tracers—The Secretary, The University, Leeds.

RESEARCH ENGINEER (good honours degree essential) for general automobile engineering problems, for investigations concerning mechanical properties (in particular fatigue strength) of materials and components, and for investigations into loadings experienced by vehicle components on the road, riding characteristics of vehicles, etc.—The Director, Motor Industry Research Association, Lindley, Nuneaton.

SCIENTIFIC OFFICERS and SENIOR SCIENTIFIC OFFICERS for project assessment groups at the Royal Aircraft Establishment, Farnborough, and at Ministry of Supply London headquarters—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.1631/53A.

"NATURE", JUNE 27, 1953
SUPPLEMENT: RECENT SCIENTIFIC AND TECHNICAL BOOKS

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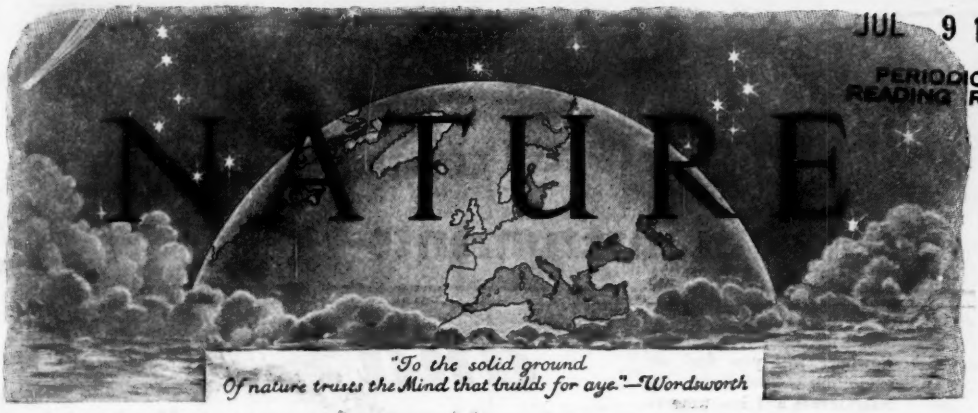

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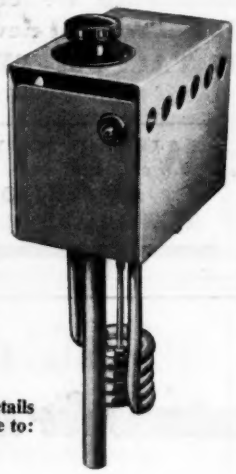

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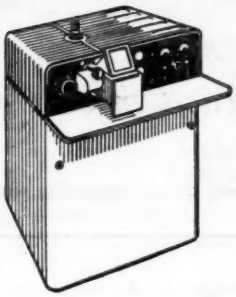

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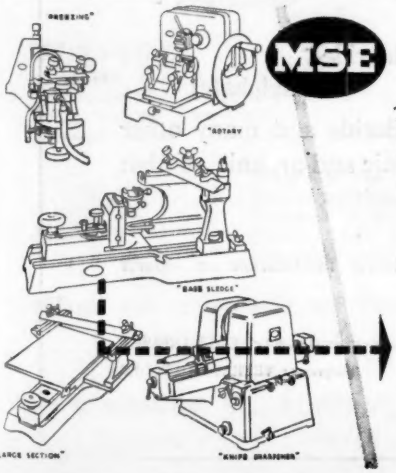

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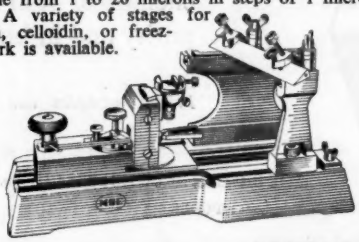

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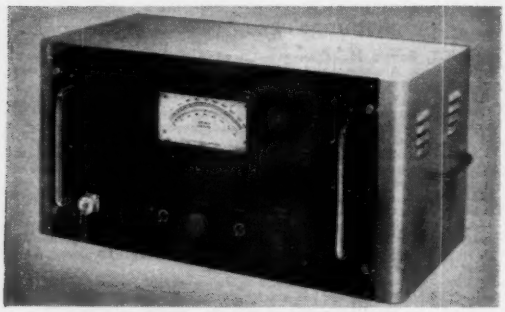

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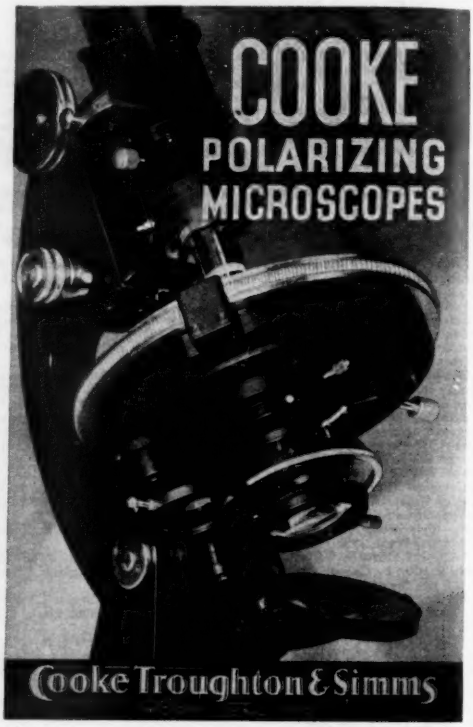

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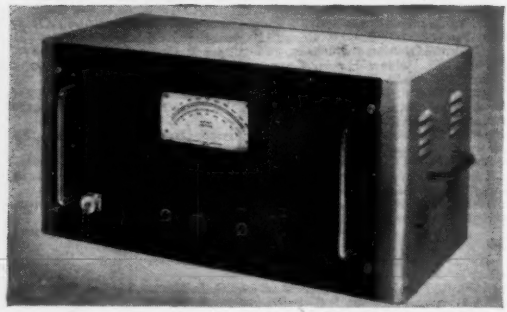

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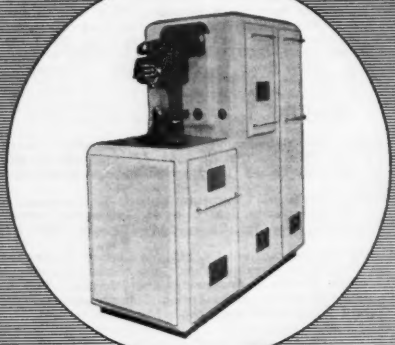

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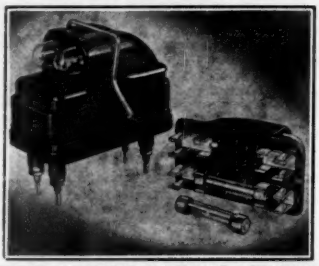

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